# ENGINEERING NEWS
AND
## AMERICAN RAILWAY JOURNAL.

Vol. XXXVI., No. 9.


### TABLE OF CONTENTS.


ENGINEERING NEWS OF THE WEEK.....129, 144
The Cernavoda Bridge over the Danube River (illustrated)..... 130
Standard Specifications for Steel; Association of American Steel Manufacturers (illustrated)..... 130
The Water-Works of Colorado Springs and the Strickler Tunnel (with inset, illustrated)..... 131
A Current Motor for Pumping Water (illustrated). 134
Insulating Rails from Metal Ties and Metal Bridge Floors (illustrated)..... 135
Basic Steel Rails..... 135
Legal Decisions of Interest to Engineers..... 135
The Sewers and Sewage Farms of Berlin (illustrated)..... 139
A New Single-Acting Compound High-Speed Engine (illustrated)..... 141
A Split Sleeve for Making Connections with Water Mains in Place (illustrated)..... 142
Water Consumption Through Metered and Unmetered Taps at Lexington, Ky..... 142
A German System of Metal Stair Construction (illustrated) ..... 142
Impermeable Covering for Stone Arches..... 143
Book Reviews ..... 144
EDITORIAL NOTES..... 136
The Cernavoda Bridge over the Danube—The Necessity of Using Derailing Switches at Grade Crossings—Municipal Investigating Committees—The Decision of the Court in the Case between the Hilton Bridge Co. and the Superintendent of Public Works of New York State—Unification of Methods of Testing Structural Material in Europe.
EDITORIAL..... 137
An Opportunity for an American Steel Rail Plant in Australia.
LETTERS TO THE EDITOR..... .....138
Steel Makers and Chemistry—A Device for Operating a Gate from a Distance by Hydraulic Power (illustrated)—The "Student" Grade of Membership in Engineering Societies—The Cutting of Water Pipe by Sand Jet at Leaks (illustrated).


THE AWARDS FOR THE MONTREAL BRIDGE PLANS called for by the Montreal Bridge Co., have at last been made. The first prize has been awarded to Mr. E. S. Shaw, of Boston, Mass., and the second prize to Mr. A. L. Bowman, of Roanoke, Va. The awards were made by Mr. Walter Shanley, and he called special attention to a plan submitted by Mr. J. W. Balet, of New York, which, though possessing peculiar merit did not comply with all the conditions of the advertisement, and could not be considered in awarding the prizes. The company has, however, awarded a special prize to Mr. Balet. The call for competitive plans for this bridge were made early in 1895, and the general plan was shown in our issue of Feb. 14, 1895, Mr. C. N. Armstrong, of Montreal, is the Managing Director of the bridge company.

A TRACK ELEVATION ORDINANCE covering a portion of the lines of the Chicago & Western Indiana and the Pittsburg, Fort Wayne & Chicago railways in Chicago, is benig prepared by the Aldermanic Committee on Track Elevation, and will be submitted to those companies for action at an early date. The elevation will begin at 71st St., and extend north to 22d St. From 47th St. north the tracks of the two companies run side by side, and all work will be done in common. Altogether about 40 subways for crossing streets will be required. This is the latest of several attempts which have been made to secure action on the part of the Chicago & Western Indiana Co., and it is stated that it will be forced if the company does not come to an early voluntary agreement. The policy of this road toward the track elevation movement and the controlling position which it occupies were explained in Engineering News, Jan. 23, 1896. The city authorities are awaiting also the decision of the Supreme Court this fall in regard to the order compelling the Union Stock Yards Co. to tear up its tracks on 40th St. If the city loses in this fight the tracks will be ordered elevated from Halstead St. to the Illinois Central R. R. tracks at once. The Aldermanic Committee has prepared plans for this change which provides that the tracks be elevated 15½ ft. on a steel structure. No street will be closed, but a number of thoroughfares will be slightly depressed, as follows: Lake Ave., 3 ft.; Wentworth Ave., 2 ft.; Bissell St., 3 ft.; Wallace St., 3 ft.; Sherman St., 4 ft.; Union Ave., 6.5 ft. At Emerald Ave. the roadway is raised 2 ft., and at Halstead St. the tracks come down to grade again.

BIDS FOR A NEW WATER SUPPLY FOR JERSEY City were received on Aug. 24 from the East Jersey Water Co. and the Rockaway & Hudson Water Co. The bids were for constructing new supply works and delivering water to the present distributing reservoirs by the million gallons, with an option of purchase of the works by the city. As was to be expected from the character of the specifications, no formal bids for filtering the present Passaic River supply were received. The bids for the gravity supply are given in the accompanying table, not including those from the East Jersey Water Co. for a supply through one 50,000,000-gallon pipe line, which was not in accordance with the specifications, which called for two or more when the full supply of 50,000,000 should be developed. Although informal, the one bid made for a filtered supply is given as of interest, but it must be remembered that it does not comply with the specifications. The United States Filtering & Purifying Co., of Philadelphia, offered to deliver filtered water to the present reservoirs at $20 for each 1,000,000 gallons up to 20; $23 for each between 20 and 30; $21 for each between 30 and 40; and $18 for each 1,000,000 gallons between 40,000,000 and 50,000,000. It would sell a 30,000,000-gallon plant, with pumps, boilers and conduits, for $1,300,000, and a 50,000,000-gallon plant for 1,918,000.

Bids for a New Water Supply for Jersey City.

| Bidder. | Source of supply. | Prices for each 1,000,000 gallons. 1 to 20 | 20 to 30 | 30 to 40 | 40 to 50 | Purchase price for works to supply. 35,000,000 galls. per day. | 50,000,000 galls. per day. |
|---|---|---|---|---|---|---|---|
| Plan A, gravity to low service, 127 ft. elevation. | | | | | | | |
| Rockaway & Hudson Water Co. | Rockaway River.. | $35.50 | $34.50 | $33.50 | $32.50 | $6,050,000 | $7,100,000 |
| Plan B, gravity to high service, 210 ft. elevation. | | | | | | | |
| Rockaway & Hudson Water Co. | Rockaway River.. | 37.00 | 36.00 | 35.00 | 34.00 | 6,375,000 | 7,400,000 |
| East Jersey Water Co. | Rockaway River*. | 37.00 | 38.00 | 36.00 | 35.00 | 7,900,000 | 7,900,000 |
| East Jersey Water Co. | Rockaway River*. | 35.00 | 36.00 | 35.00 | 34.00 | 6,945,000 | 6,945,000 |
| Plan C, at least one-third to high, and balance to low service. | | | | | | | |
| Rockaway & Hudson Water Co. | Rockaway River.. | 36.50 | 35.50 | 34.50 | 33.50 | 6,250,000 | 7,250,000 |
| East Jersey Water Co. | Neennock Lake & Wynockie River | 37.00 | 38.00 | 37.00 | 36.00 | 7,950,000 | 7,950,000 |

*From different points of intake.

THE CAISSON FOR THE INTAKE CRIB of the northwest water supply tunnel at Chicago, Ill., was launched Aug. 19 by Fitzsimons & Connel, the contractors for the submarine section of the tunnel. This caisson is 112 ft. in diameter, with walls 20 ft. high. Altogether 750,000 ft. B. M. of timber and 93 tons of steel and iron will be used in its construction by the time it is ready for sinking. The location of the crib will be three miles from shore and it is expected that the sinking of the caisson and the masonry for the crib will be completed this year. The structure was designed by Mr. John Ericsson, Assistant City Engineer, under the direction of City Engineer L. B. Jackson.

WATER FROM THE HARBOR for increasing the fire protection of Boston has been proposed from time to time. It is reported that the question is now to be investigated by a joint committee of aldermen and councilmen, who will visit a number of cities to study this and other matters related to fire departments. The Boston "Journal" comments editorially on the trip under the heading "Eight to One," or eight politicians and one expert," and asks, "could not eight experts and one politician learn more to the advantage of the Boston Fire Department?"

THE CONSTRUCTION OF A SANITARY AND DRAINage Canal west from the Calumet district, at South Chicago, Ill., is again rumored. It is stated that the intention is to follow the survey made by the U. S. Engineers, some years ago, which is practically the route of the present "Sny" feeder to the Illinois & Michigan Canal. The cost is estimated at from $10,000,000 to $15,000,000, and the method of procedure will be to organize a sanitary district similar to that organized to construct the Chicago Drainage Canal and raise the money by tax levies and bond issues as provided by the sanitary district law of the state of Illinois. The large land owners in the Calumet district are said to be at the head of the project, and the opinion is expressed that the scheme is simply an attempt to boom land values and will never get beyond the paper stage. Furthermore, it is charged that the assessed valuation of the district cannot possibly provide the necessary money from bonds and taxes at the rates of issue allowed by the state laws.

A COMBINED OUTLET SEWER AND GARBAGE chute has been built at Niagara Falls, N. Y. The sewer is of steel, about 30 ins. in diameter, and 220 ft. long, extending from a 24-in. sewer at Bath Ave., over and down the bluff, which is here nearly 200 ft. high, to the water's edge. The sewage and garbage was formerly discharged over the bank, but the construction of the Gorge Electric Ry., near the water line, made this practice undesirable, to say the least. Mr. W. W. Reed is city engineer of Niagara Falls and gave us the above information. Mr. John Mahar, of Tonawanda, was contractor for the work, which was done last May. Mr. Reed says the new outlet is giving satisfaction.

GAS-ENGINE STREET CARS on the Luehrig system (Eng. News, Jan. 24, 1895) have been put in operation on the new Blackpool, St. Ann's & Lytham Tramway, of England, and are said to be the first cars to be operated by gas in that country. Each car has a two-cylinder Otto gas engine of 15 HP., and reservoirs holding a supply of gas for a run of eight miles. The gas is obtained from the town mains and compressed at the company's station, and the charging is done by means of an india-rubber pipe, occupying but about one minute. The track from Blackpool to St. Anne's is for the most part along a country road, and some rather steep grades are easily mounted, the cars running at a speed of eight miles an hour, though they are said to be capable of running 12 or 14 miles per hour. Each car carries 40 passengers. Cars on this system are in operation at Berlin, Dresden and Dessau, in Germany.

THE HOLLAND SUBMARINE TORPEDO-BOAT, now being built for the U. S. Government at Baltimore, is nearly completed and her builders expect that she will be ready for her trial trip in September next. If she succeeds in meeting the requirements of the contract this boat may work as great a revolution in naval warfare as did the "Monitor."

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the derailment, on Aug. 22, of a westbound freight train, near Horse Plains, Mont., on the Northern Pacific R. R. As the train was passing over a high embankment the bank settled and slid out, throwing the train into the Clark's Fork River. Four trainmen were killed. It is supposed that an underlying quicksand bed caused the accident.——A rear collision of westbound freight trains, at Valencia, Pa., on the Pittsburg & Western Division of the Baltimore & Ohio R. R., Aug. 24, caused the fouling of the eastbound track by wreckage, and the limited express ran into the obstruction, the engine and two cars going over the bank and most of the cars being wrecked. About 20 persons were injured, four being fatally injured.

A BOILER EXPLOSION occurred Aug. 19 on the works of the sewer in Rockland Park, Rochester, N. Y.; one man was fatally injured and several others more or less injured. ——The boiler of the steamer "Manitou," on Clark's Lake, at Jackson, Mich., exploded Aug. 20, but nobody was killed.——A boiler in the car shops of the Pennsylvania R. R., at Pavonia, N. J., exploded Aug. 21, and one man was badly hurt.

A LOCOMOTIVE BOILER EXPLOSION occurred Aug. 16, on the Colorado Midland R. R., at Basalt, Colo. A switch engine was standing at the station when its boiler burst and two men were injured.

AN EXPLOSION OF GUNPOWDER occurred at the works of the Tomnicken Powder Mfg. Co., at Derringer, Pa., Aug. 20, killing one man and injuring three others.

A COLLISION WITH AN ICEBERG on the Atlantic Ocean, Aug. 19, caused the loss of the tramp steamer "Moldava," carrying coal from Cardiff, Wales, to Halifax, Nova Scotia. The ship struck about 4.30 p. m., during a heavy fog, and in a few hours the vessel went down. The crew took to the boats and were picked up by the "Circassia," of the Anchor Line.

TWO MORE CASES OF RUNAWAY ELECTRIC CARS are reported: On Aug. 22 a car on the Bergen St. line of the Nassau Electric Co., Brooklyn, N. Y., got beyond control on the grade and left the track at the curve at the corner of Bergen and Hoyt Sts., running onto the sidewalk. Four of the eight persons in the car were slightly injured. The motorman said the brakes were out of order.——A car on the new line up the Catoctin Mountain, from Frederick, Md., to Braddock Height, got beyond control while coming down the grade, Aug. 23. The car crossed a high crestle and then jumped the track at a curve and fell over on its side. The car had seats for 45 persons but carried about 120 persons at the time, and about five persons were badly hurt, while some 30 more were cut and bruised. Passengers tried to put on the brakes but it is said they would not work.

THE COLLAPSE OF A NEW FREIGHT SHED being built by the New York, New Haven & Hartford R. R., on Congress St., South Boston, Mass., occurred Aug. 19, by which one man was killed and ten were injured. The building was to be 1,000 × 60 ft., and about 600 ft. of its length had been built, and the wooden roof trusses were being put up at the time of the accident.

## THE CERNAVODA BRIDGE OVER THE DANUBE RIVER.

The recent formal opening to traffic of the great bridge over the Danube in Roumania, after 5½ years spent in construction, has recalled the attention of engineers to a work possessing many features of unusual interest. It was in 1890 that the Roumanian government determined to undertake the bridging of the Danube, at Cernavoda, its purpose being to provide a direct route from the interior to the Black Sea. The Fetesti-Cernavoda Ry., whose track crosses the new structure, now gives an almost direct outlet to the ports on the Black Sea, and it is thought that the advantage thus gained will be felt especially in the transportation of agricultural products. At the point on the river where Cernavoda is located, and where it was determined to place the bridge, the Danube is divided into two branches by the island Balta. The river flows in a northerly direction at this point and it is the easterly channel that retains the name of Danube, the westerly being called the Borcea River. The island is swampy, and at certain times is entirely covered with water. It is between seven and eight miles in width. Two bridges are thus necessitated, and on the island a long stretch of embankment with an open viaduct about half way across. The total length of iron structure is about 13,460 ft., or 2.6 miles, this being divided as follows: Cernavoda bridge, 2,460 ft.; approaches to Cernavoda bridge, 3,000 ft.; viaduct on Balta island, 4,770 ft.; Borcea bridge, 1,380 ft.; and approaches to last named, 1,840 ft. The first two mentioned portions may be seen in the accompanying engraving, showing the Danube bridge in course of construction. The piers for the 15 spans of the approach lead away westward to the end of the embankment in the distance.

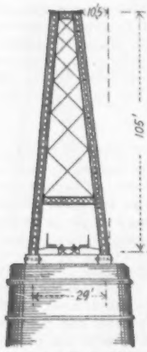


Fig. 2.—End Elevation of Pier, showing Inclination of Trusses.

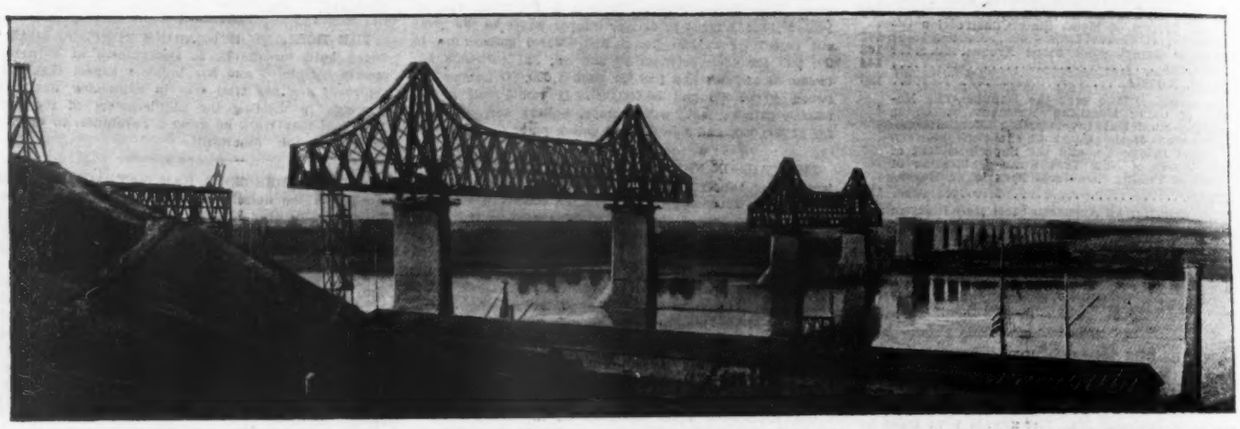
The contract for the construction of the Cernavoda bridge, not including approaches, was awarded to the Societe de Fives-Lille, of France, for $1,570,000. This estimate was based on a rate for the superstructure of $135.40 per ton weight, including erecting and painting. The estimated weight was 5,150 tons; the actual is about 5,500. The construction of the river piers was attended with unusual difficulties. It was required that they be built on bed-rock, and to accomplish this it was necessary to sink the caissons to a depth of 101 ft. below water level. Much difficulty was experienced in working at this great depth, the extreme pressure proving fatal to a number of laborers. The total height of the pier is 207 ft., giving the floor of the bridge an elevation of 121 ft. above high water level. The dimensions of the various portions of the piers and the materials used in their construction are indicated in Fig. 3.

There are four river piers, each two supporting a span 790 ft. long, consisting of two end cantilevers, each 164 ft. in length, and a central truss construction. The spaces remaining are filled with three 295-ft. truss spans, having half parabolic top chords. An elevation of the bridge, showing length of various parts, is given in Fig. 1. The width of the bridge at the floor level varies from 29 ft. at the piers to 21 ft. at the ends of the cantilevers. These widths are maintained throughout the 467 ft. and the 295 ft. portions. Fig. 2 is the end elevation of the superstructure at a pier. One of the most noticeable features of the construction, the rapid narrowing from bottom to top chords, is here shown. The slope of the trusses is 1 : 10 with the vertical. Basic open hearth steel of a tensile strength of from 59,000 to 68,000 lbs. per sq. in. is used on the main bridge. The elongation at failure in tests of this steel was about 20%, and the elastic limit was about 34,000 lbs. per sq. in. On the approaches a milder grade of steel was used.

The two main spans of the superstructure, as shown in the photograph of the bridge, were erected at the same time with the piers themselves. They were first lifted by trestles to high water level. From that point they were raised by hydraulic jacks on the piers. The jacks were supported on pipes imbedded in the masonry of the piers, there being four pipes in each pier, used in pairs. While one pair was being extended, the other supported the weight on the jacks. In this way ample space for working at the top of the piers was obtained. Fig. 4 shows the floor construction, with the method of imbedding the ties in cement, the whole being underlaid with iron. The bridge is crossed by but a single track.

The approaches and viaduct present no features of particular interest, except, perhaps, the solidity and permanency of construction prevailing throughout. The masonry piers are surmounted by trusses of ordinary type. The embankment is built in a substantial manner, with a generous use of rip-rap. The Borcea bridge is similar in appearance to the larger structure. It has but two river piers, which support a 790-ft. span like the central spans of the Cernavoda bridge, and connection to shore is made by two 295-ft. half parabolic spans, as before. The bridge floor is 62 ft. above high water level.

The total cost of the work, including both bridges and all approaches, was, in round numbers, $6,000,000.


CANTILEVER BRIDGE OVER THE DANUBE RIVER AT CERNAVODA, AUSTRIA. VIEW SHOWING TWO MAIN SPANS COMPLETED AND THE PIERS SUPPORTING THEM UNDER CONSTRUCTION.

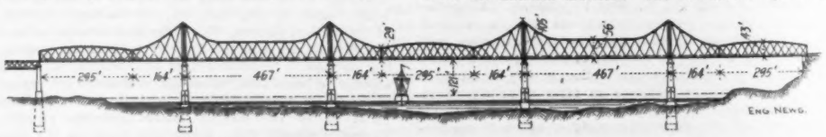


Fig. 1.—ELEVATION OF THE CERNAVODA BRIDGE.

## STANDARD SPECIFICATIONS FOR STEEL; ASSOCIATION OF AMERICAN STEEL MANUFACTURERS.

The Association of American Steel Manufacturers has recently revised its standard specifications, and we are indebted to Mr. H. H. Campbell, Secretary of the Association, for an official copy of the specifications as now adopted. After the adoption of certain changes it was deemed advisable to reword the entire matter, the revised specifications being then submitted to three members of the association, and after their criticisms the corrected specifications were sent to all the members. We print below the final form of the specifications in full; and this form has been approved by quite a number of the members and will, without doubt, be the final one. As will be noted by comparing these with the specifications first adopted, the consideration of the chemical, as well as the physical properties of structural steel in the later specifications constitute the chief points of difference and a marked step in advance, as pointed out in a letter from a correspondent in another column.

**Standard Specifications Governing the Chemical and Physical Properties of Structural and Special Open Hearth Plate and Rivet Steel as Adopted by the Association of American Steel Manufacturers on Aug. 9, 1895; Revised July 17, 1896.**

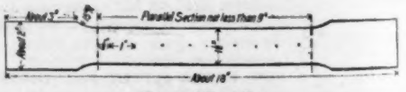
### Structural Steel.

Process of Manufacture.—(1). Steel may be made by either the Open Hearth or Bessemer process.

Test Pieces.—(2). All tests and inspections shall be made at places of manufacture prior to shipment.

(3). The tensile strength, limit of elasticity and ductility shall be determined from a standard test piece cut from the finished material. The standard shape of the test piece for sheared plates shall be as shown by the following sketch:

On tests cut from other material, the test piece may be either the same as for plates or it may be planed or turned parallel throughout its entire length. The elongation shall be measured on an original length of 8 ins., except when the thickness of the finished material is 5-16 in. or less, in which case the elongation shall be measured in a length equal to sixteen times the thickness;



Form of Test Bar.

and except in rounds of ⅝-in. or less in diameter, in which case the elongation shall be measured in a length equal to eight times the diameter of section tested. Two test pieces shall be taken from each melt or blow of finished material, one for tension and one for bending.

(3a). Material which is to be used without annealing or

further treatment is to be tested in the condition in which it comes from the rolls. When material is to be annealed or otherwise treated before use, the specimen representing such material is to be similarly treated before tested.

(4). Every finished piece of steel shall be stamped with the blow or melt number, and steel for pins shall have the blow or melt numbers stamped on the ends. Rivet and lacing steel, and small pieces for pin plates and stiffeners, may be shipped in bundles securely wired together with a blow or melt number on a metal tag attached.

Finish.—(5). Finished bars must be free from injurious seams, flaws or cracks, and have a workmanlike finish.

Chemical Properties.—(6). Steel for buildings, train sheds, highway bridges and similar structures shall not contain more than 10% of phosphorus.

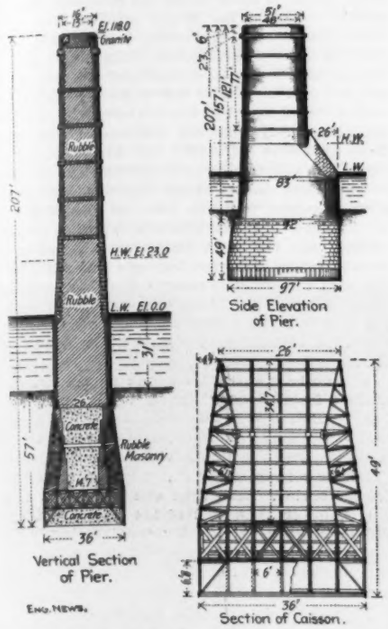



**Fig. 3.—Elevation and Sectional Views of Pier and Caisson.**

(7). Steel for railway bridges shall not contain more than .08% of phosphorus.

Physical Properties.—(8). Structural steel shall be of three grades: rivet, soft and medium.

Rivet Steel.—(9). Ultimate strength, 48,000 to 58,000 lbs. per sq. in. Elastic limit, not less than one-half the ultimate strength. Elongation, 26%. Bending test, 180° flat on itself, without fracture on outside of bent portion.

Soft Steel.—(10). Ultimate strength, 52,000 to 62,000 lbs. per sq. in. Elastic limit, not less than one-half the ultimate strength. Elongation, 25%. Bending test, 180° flat on itself, without fracture on outside of bent portion.

Medium Steel.—(11). Ultimate strength, 60,000 to 70,000 lbs. per sq. in. Elastic limit, not less than one-half the ultimate strength. Elongation, 22%. Bending test, 180° to a diameter equal to thickness of piece tested, without fracture on outside of bent portion.

Pin Steel.—(12). Pins made from either of the above-mentioned grades of steel shall, on specimen test pieces

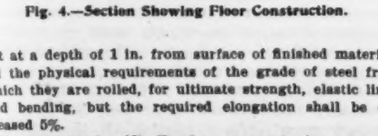



**Fig. 4.—Section Showing Floor Construction.**

cut at a depth of 1 in. from surface of finished material, fill the physical requirements of the grade of steel from which they are rolled, for ultimate strength, elastic limit and bending, but the required elongation shall be decreased 5%.

Eye-Bar Steel.—(13). Eye-bar material, 1½ ins. and less in thickness, made of either of the above-mentioned grades of steel, shall, on test pieces cut from finished material, fill the requirements of the grade of steel from which it is rolled. For thicknesses greater than 1½ ins. there will be allowed a reduction in percentage of elongation of 1% for each ¼-in. increase of thickness, to a minimum of 20% for medium steel and 22% for soft steel.

Full Size Test of Steel Eye-Bars.—(14). Full size test of steel eye-bars shall be required to show not less than 10% elongation in the body of the bar, and tensile strength not more than 5,000 lbs. below the minimum tensile strength required in specimen tests of the grade of steel from which they are rolled. The bars will be required to break in the body, but should a bar break in the head, but develop 10% elongation and the ultimate strength specified, it shall not be cause for rejection, provided not more than one-third of the total number of bars tested break in the head; otherwise the entire lot will be rejected.

Variation in Weight.—(15). The variation in cross-section or weight of more than 2½% from that specified will be sufficient cause for rejection, except in the case of sheared plates, which will be covered by the following permissible variations, provided that no plate shall be rejected for light gage measuring 1-100-in. or less below the ordered thickness.

(15a). Plates 12½ lbs. per sq. ft. or heavier when ordered to weight shall not average more than 2½% variation above or 2½% below the theoretical weight.

(15b). Plates from 10 to 12½ lbs. per sq. ft. when ordered to weight shall not average a greater variation than the following: Up to 75 ins. wide, 2½% above, or 2½% below the theoretical weight; 75 ins. and over, 5% above or 5% below the theoretical weight.

(15c). Rectangular plates, ¼-in. thick and heavier, when ordered to gage, shall not average a greater variation than the following:

Table of Allowances for Overweight for Rectangular Plates.

(Note.—The weight of 1 cu. in. of rolled steel is taken at 0.2833 lbs.)

| Plate | Width of plate: Up to 75 ins. | 75 to 100 ins. | Over 100 ins. |
|---|---|---|---|
| ¼-in. thickness ..... | 10 % | 14 % | 18 % |
| 5-16-in. " ..... | 8 % | 12 % | 16 % |
| ⅜-in. " ..... | 7 % | 10 % | 13 % |
| 7-16-in. " ..... | 6 % | 8 % | 10 % |
| ½-in. " ..... | 5 % | 7 % | 9 % |
| 9-16-in. " ..... | 4½ % | 6½ % | 8½ % |
| ⅝-in. " ..... | 4 % | 6 % | 8 % |
| Over ⅝-in. thickness.. | 3½ % | 5 % | 6½ % |

(15d). Rectangular plates under ¼-in. in thickness when ordered to gage shall not average a greater variation than the following:

| Thickness of plate. | Width of plate: Up to 50 ins. | 50-in. and abv. |
|---|---|---|
| ¼-in. up to 5-32-in. ..... | 10 % | 15 % |
| 5-32-in. up to 3-16-in..... | 8½ % | 12½ % |
| 3-16-in. up to ¼-in ..... | 7 % | 10 % |

Structural Cast Iron.

(1). Except when chilled iron is specified, all castings shall be tough gray iron, free from injurious cold-shuts or blow-holes true to pattern, and of a workmanlike finish. Sample pieces 1 in. square, cast from the same heat of metal in sand molds, shall be capable of sustaining, on a clear span of 4 ft. 8 ins., a central load of 500 lbs. when tested in the rough bar.

Special Open Hearth and Rivet Steel.

Test Pieces.—(1). All tests and inspections shall be made at place of manufacture prior to shipment.

(2). The tensile strength, limit of elasticity and ductility, shall be determined from a standard test piece cut from the finished material. The standard shape of the test piece for sheared plates shall be as shown by the sketch.

On tests cut from other material the test piece may be either the same as for plates, or it may be planed or turned parallel throughout its entire length. The elongation shall be measured on an original length of 8 ins., except when the thickness of the finished material is 5-16-in. or less, in which case the elongation shall be measured in a length equal to sixteen times the thickness; and except in rounds of ⅝-in. or less in diameter, in which case the elongation shall be measured in a length equal to eight times the diameter of section tested. Four test pieces shall be taken from each melt of finished material; two for tension and two for bending.

(3). Material which is to be used without annealing or further treatment is to be tested in the condition in which it comes from the rolls. When material is to be annealed or otherwise treated before use, the specimen representing such material is to be similarly treated before testing.

(4). Every finished piece of steel shall be stamped with the melt number. Rivet steel may be shipped in bundles securely wired together, with the melt number on a metal tag attached.

(5). All plates shall be free from surface defects and have a workmanlike finish.

Chemical Properties.—(6). The maximum allowable limits of phosphorus and sulphur shall be as follows:

(6a). On flange and boiler steels, .06% of phosphorus and .04% of sulphur.

(6b). On fire box and extra soft steels, .04% of phosphorus and .04% of sulphur.

(6c). On boiler rivet steel, .04% of phosphorus and .04% of sulphur.

Physical Properties.—Extra Soft Steel. (7). Ultimate strength, 45,000 to 55,000 lbs. per sq. in. Elastic limit, not less than one-half of the ultimate strength. Elongation, 28%. Cold and quench bends, 180° flat on itself, without fracture on outside of bent portion.

Fire Box Steel. (8). Ultimate strength, 52,000 to 62,000 lbs. per sq. in. Elastic limit not less than one-half the ultimate strength. Elongation, 26%. Cold and quench bends, 180° flat on itself, without fracture on outside of bent portion.

Flange and Boiler Steel. (9). Ultimate strength, 52,000 to 62,000 lbs. per sq. in. Elastic limit, not less than one-half the ultimate strength. Elongation, 25%. Cold and quench bends, 180° flat on itself, without fracture on outside of bent portion.

Boiler Rivet Steel. (10). Steel for boiler rivets shall be made of the extra soft quality specified in paragraph No 7.

Variation in Weight.—The allowances for overweight are to be the same as given in paragraph No. 15, under the head of Structural Steel.

## THE WATER-WORKS OF COLORADO SPRINGS AND THE STRICKLER TUNNEL.

(With inset.)

The first water-works system for Colorado Springs, Colo., was completed in 1878, and since that time it has undergone a nearly continuous process of development and improvement until it has now reached a stage which is expected to render any further improvement unnecessary for many years. By the end of 1896 it is expected that the final construction of the plant as planned will be completed. Altogether the work of development has been an arduous one, beset with legal complications and engineering problems of annoying, if not of exceedingly difficult character. As an example of the variety of problems encountered by some of our American cities in securing a water supply, and likewise of the methods adopted to overcome these problems, the work is unusually instructive, but further than this it comprises reservoir, pipe line and tunnel constructions of unusual character. The tunnel work particularly is a task worthy of extended mention, and in the accompanying illustrations and this description, the salient features of the work are given in such detail as their importance seems to warrant. For the information from which this article has been prepared we are indebted to Mr. H. I. Reid, City Engineer, Colorado Springs, Colo., who has planned and carried out the work in all its details. The character of his task and the efficiency with which it has been accomplished is testified by the matter which follows.

The accompanying map, Fig. 1, shows the water-works system of Colorado Springs as planned and constructed. All the various pipe lines, reservoirs and other constructions are shown as far as their general location is concerned.

Original System.

The first system of water-works constructed in 1878 consisted of six miles of 6-in. main, from Ruxton Creek in the town of Manitou to storage reservoir No. 1, and a 12-in. distributing main from the reservoir into town. The reservoir was located 200 ft. above City Hall datum and held 1,250,000 gallons. The main being laid with but a slight covering of earth and the intake, according to reports, being improperly designed, it froze solid the first winter. To correct the error a new main of 10 ins. and 8 ins. diameter was laid in 1880. Altogether this experiment cost the city $40,000.

New System.

In 1884, Mr. H. I. Reid was employed by the city to investigate the different sources of water supply preparatory to preparing a general plan for future operations. Careful study of all details regarding supply, drainage area, precipitation, freedom from pollution, and comparative cost led to but one conclusion, and this was that the Pike's Peak region was the proper source of supply. The city which was to be supplied, Colorado Springs, is a health and tourists' resort, and consequently few restrictions are placed upon the use of water. Lawn sprinkling is permitted free of charge and no meters are used. Naturally the citizens were not slow to take advantage of this freedom, and the consumption of water exceeds 300 gallons per capita per day. In view of these facts it was assumed that it was desirable to plan the system for a population of 25,000 people using 200 gallons per day each, and this was done.

Storage Reservoir No. 2.—The first work done was to build a second storage reservoir about 400 ft. from the reservoir of the old system. This site was the Mesa, having a slope of 4% to the south and was the only one available for a reservoir unless a new supply main was to be constructed, which was not at once possible. At the location selected the reservoir could be supplied by a by-pass around reservoir No. 1 from the original 8-in. pipe. Besides this by-pass a new pipe was laid connecting the two reservoirs at high water line, and a 16-in. distributing main was carried into the city. Briefly described the new reservoir has a capacity of 14,500,000 gallons and being excavated in the side hill has embankments on three sides only. The cross-section of these embankments is 20 ft. wide on top, with an inside slope of 3 to 1 and an outside slope of 2½ to 1. All pipes through the embankment are incased in concrete masonry and have projecting collars at each joint. In regard to the construction of this reservoir the engineer, Mr. H. I. Reid, writes:

In constructing these embankments the writer learned from actual experience two important facts, relating to safe construction: (1) A large percentage of clay is not desirable, and (2) too great a quantity of water used in wetting the embankment is worse than no water. More especially is this true if a large amount of clay is used.

New Supply Mains.—As stated above, the new storage reservoir No. 2 took its water from the old 8-in. supply main. This provided for temporary demands, but it was necessary to construct an additional supply main to provide for the assumed demand of 5,000,000 gallons per day. Making due allowances for the original pipe it was found that a 16-in. supply main was needed, and after some opposition, on account of cost, its construction was begun in February, 1889, and completed in December of the same year. During this period several months' delay were caused by litigation for right of way through a neighboring town. Heavy cast-iron pipe was used and considerable time was spent to secure the best possible location and alinement. The pipe was laid on regular curve and tangent alinement, and all depressions and summits avoided. Where possible, without too great deflection, the line follows the streets and highways. The general profile of the pipe line is as follows: Elevation of intake, 6,619 ft.; elevation of reservoir, 6,226 ft.; elevation of City Hall, 6,026 ft.; length of line, 6.73 miles.

This 16-in. main does not enter the new storage reservoir, but connects with the 16-in. distributing main running from it as before described. Thus the new reservoir acts as a stand-pipe for the new supply main. When there is a heavy draft, water is drawn both from the supply main and the reservoir; but otherwise the water backs up from the main into the reservoir. Provisions are made for cutting off the reservoir supply so that if desired—in case of a large fire, for example—the water may be taken direct from the main with a pressure due to a head of 593 ft. Such use has never yet been made, however, and will not be until a pressure regulator has been placed so that the pressure cannot exceed 150 lbs. per sq. in.

All the work on the pipe line, and, indeed, all other work, except where especially mentioned, was done by day labor, and regarding it City Engineer Reid writes:

The practical observations of the writer upon this work are that much time given to careful alinement and to minute details of construction is amply rewarded in the increased supply of water and the small cost of maintenance. This was practically demonstrated. We had parallel mains with the same intake point. Points were selected where the length and head were the same for both mains and the discharge of each was measured by a current meter. Making due allowance for the greater length of time the old pipe had been used, although this pipe is apparently as free from incrustation now as when laid, it was found that the old pipe had a measured capacity less than the calculated capacity for rough pipe, while the new pipe had a measured capacity somewhat greater than the calculated capacity for smooth pipe.

Bear and Cheyenne Creek Supplies.—As soon as the construction of the Ruxton Creek supply main was completed, work was begun on an additional main from Bear Creek, it having been previously determined that the water from this stream could be injected into the system by a pipe line 2½ miles long, and further, that at a point some eight miles up the stream Cheyenne Creek could be diverted, carried through a low pass, and emptied into Bear Creek, thus saving the cost of eight miles of pipe which would have been necessary had Cheyenne Creek been tapped at a lower point near the mouth of the canyon. A point was selected for intake purposes on Bear Creek at the same elevation as the Ruxton Creek intake. From this point a 12-in. main was constructed to the city. Some four miles above the intake the waters of Cheyenne Creek were let into Bear Creek by a ditch between the two streams. Subsequently, sewer pipe was laid in this ditch and it greatly diminished the loss of water. This work being completed, attention was turned toward constructing storage reservoirs in the Pike's Peak region. The first work was the Lake Moraine reservoir, which is described in the following excerpt from notes sent us by City Engineer Reid:

Lake Moraine Reservoir.—This reservoir is located near the head waters of Ruxton Creek, about eleven miles west of Colorado Springs and at an elevation of 10,246.8 ft. Its capacity is 492,000,000 gallons and the total area covered is 96 acres, wholly within the original boundaries of the Pike's Peak Military Reservation. In speaking of this basin the eminent geologist, Prof. Arthur Lakes wrote: "At one time the whole valley was occupied first by a glacier and later by a lake over a mile in length, dammed back by a wide moraine thrown right across the valley; but at some time this principal moraine was broken through and the waters of the lake were discharged down a steep narrow ravine along the path of what is called Ruxton Creek, leaving only the small circular lake behind it."

This little lake, 24 ft. deep and covering an area of about 15 acres, was formerly known as "Mystic Lake," probably from the fact that it has no visible inlet nor outlet yet is always full of pure and clear water. Later, however, it was called Lake Moraine. On the opposite side of the valley there is a basin which is almost the exact duplicate of Lake Moraine in form and capacity, yet holding no water until submerged, although its lowest point is lower than its counterpart and many feet below Ruxton Creek which flows between. The cross section profile, Fig. 2, illustrates this better than words can express. To construct the reservoir what we did was simply to repair the breach which caused the drainage of the ancient lake and to utilize the spill-way which nature had so kindly prepared and used in ages gone by. This spill-way is indeed a suggestion, which the engineer is wise in copying where possible. It is located 700 ft. distant from the dam. The water flows off from the side of the reservoir and, making a wide detour, comes back into the main stream one-half mile below the dam. Between the dam and spill-way is a morainal deposit 30 ft. higher than the dam.

The dam, Fig. 3, is 422 ft. long on top; 150 ft. long on the bottom, and has a top width of 20 ft. The inner slope is 3 to 1 and the outer slope 2 to 1. Both slopes are covered to a depth of 2 ft. from toe to crest with broken granite. The crest of the dam is 8 ft. above high water level and the greatest height of the dam is 35 ft.

The materials used were good for the purpose intended, being composed of coarse gravel, fine gravel, sand, and clay in about the proportions 4, 3, 1, and 2, respectively. The entire base of the dam was stripped to a depth below frost line and the puddle trenches carried down to a depth of 14 ft. below the surface or 4 ft. into the clay. Test pits dug 11 ft. deeper failed to define the depth of the clay stratum. It required a great deal of blasting to clear the borrow pits of granite boulders left by glacier drift, but these were utilized in slope paving and for the valve chamber, although for this latter use they were very poorly adapted. In fact we had to select such stone as somewhat resembled a cubical form, as dressing was out of the question.

The valve chamber, Fig. 4, here, as in all of our mountain dams, is placed back free from the action of ice, but always in excavation in the natural earth at the end of the dam. In this case the outlet pipe parallels the inner toe of the slope to the valve chamber, on the high water line, thence turns nearly at right angles to center line of dam and passes to the outer toe. The pipe from chamber to inlet is under pressure, but we find this preferable to having the chamber in the water. The pipe thoughout is encased in concrete and a collar is placed at 12-ft. intervals. The winter weather at this altitude is severe, and from June 1 to Nov. 1 was the only time at which work could be carried on during the year. At the time construction was commenced there was no road nearer than four miles from the site, and all materials had to be carried in on burros over the old United States Pike's Peak trail. This was laborious and costly, and we immediately began constructing a road to connect with the Seven Lakes toll road four miles distant and in an opposite direction to Colorado Springs. This gave us a wagon road inlet, but the road mentioned is very steep and the length about 24 miles, or twice the distance to town over a direct line. There is now a wagon road completed direct down Bear Creek Canyon, also a road connecting with the Pike's Peak rack railway at Mountain View station.

Proposals for this work were received and rejected because excessive; received a second time and again rejected for the same cause, and finally it was let by contract to furnish tools and all labor at so much per day. Mr. David McShaw, of this city, was the contractor. The lowest bid received for this work by yardage amounted to $28,000, and the cost of the work as carried out was $22,000. Mr. Delos Durfee, one of the present assistants in this office, was resident engineer in charge of the work.

Provision was made for wetting the dam, but nature is very lavish with her down-pour of rain at this altitude during the summer months, so that it was a more difficult matter to keep the work sufficiently dry and not lose too much time.

The dam is built up in parallel layers, 4 to 6 ins. thick, but the middle third was kept about 2 ft. higher than the outer thirds, which slope gently from the center in order to quickly shed the rain fall. We find it a wise precaution in all dams and absolutely necessary in the Mountain System, to lower the water 4 to 6 ft. below high water line every fall before the reservoir is frozen over. If this is not done the ice displaces the riprap and leaves the dam in a loosened condition for wave action at high water line, all of which is avoided by lowering in early fall and quickly covering the ice line by water in spring time.

Beaver Creek Pipe Line.—It was known that the waters from Middle Beaver Creek, on the west side of the ridge, could be diverted across Seven Lakes Divide and emptied into Ruxton Creek above Lake Moraine reservoir; also, that West Beaver Creek could be turned into Middle Beaver Creek above such a conduit either by means of a flume or a tunnel, and further, that the best available location for storage reservoirs was to be found on these streams. It was therefore deemed advisable to obtain water rights on Beaver Creek and to this end prices were obtained on several ranches having the oldest and best water rights of this stream. These ranches were located near the confluence of Beaver Creek with the Arkansas River, some 40 miles below the point where it was desired to divert the former stream. Two questions now arose: (1) Having purchased a water right on lower Beaver Creek, could the point of diverting this water be transferred 40 miles up the stream?, and (2), should this be legal, could this diverted water be turned into another stream having an entirely different watershed? To decide these questions a friendly suit was instituted between the city of Colorado Springs and Mr. Wm. Strickler and carried to the Supreme Court, where it was decided that the point of diversion could be changed without effecting priority. In the second case the state legislature enacted a law permitting the diversion from one watershed into a different one and also enacted the above court decision into a law. These questions being settled, the city purchased two ranches for $28,000, the combined capacities of whose water rights were 17.12 cu. ft. per sec.

Immediately work was begun on the necessary conduit from Beaver Creek to Ruxton Creek. The conditions were as follows: About 1¾ miles southwest of Lake Moraine dam is the lowest pass in the range known as Seven Lakes Divide. The elevation here is 11,070 ft., or 812 ft. higher than Lake Moraine. Less than one mile distant, and 120 ft. lower than this divide is the valley of Middle Beaver Creek. By constructing a pipe line 8,400 ft. long sufficient elevation is gained to carry the waters of this creek and its tributaries to Seven Lakes Divide whence it flows down the mountain side into Lake Moraine reservoir. A year previous to this construction a ditch was built for the same purpose and is still used to some extent in the summer time. This pipe is steel, 16 ins. in diameter and light weight in order to avoid excess weight in hauling to the works. Its capacity is 7½ cu. ft. per sec. and it carries the full capacity of the stream except during the two summer months when the ditch is also used if needed. This work was contracted but before half completed the contractor "threw up the job" and the work was completed by force account. It is proper to state here that while the greater portion of these water-works has been constructed by day labor, it was because the engineers were never able to secure a reasonable bid for any mountain work until the past year. The altitude, climate and difficulty in conveying materials, together with the uncertain character of the work, all made the bids excessive, as was afterwards proven by day labor construction.

Ruxton Creek Extension.—Hardly had the Beaver Creek pipe line been completed when a new problem arose. The Manitou & Pike's Peak Ry. is constructed very nearly along the water grade of Ruxton Creek, and this water formerly so clear and pure was rendered more or less muddy from grade washings and from the tourist travel and campers. The stream, it was thought, polluted the water to too great an extent for drinking purposes of a health resort, and it was deemed advisable to extend the supply main up stream a distance of three miles, where the road leaves the canyon. Previous to this time, however, Congress had given the city 700 acres of land surrounding Lake Moraine, so the city now purchased from private parties all the lands on either side of the canyon from the Lake Moraine grant to the rock road, thereby saving cost of constructing 2½ miles of pipe to reach the lake and also receiving the flow from the numerous branches and springs below the lake.

This construction was expensive, as is plainly indicated by the views, Figs. 5 and 6. A heavy

wrought iron pipe with Mathewson joints was used, anticipating the early use of this water for power purposes, as well as domestic uses. This pipe line has a total fall of 2,428.8 ft. without a break, but has no dips or summits. The center line is parallel with and 8 ft. from the center of the railway, except at one point where it diverges for a distance of 700 ft. to avoid heavy blasting in the granite cut through which the road posses. On this diverging line huge masses of granite boulders were encountered and at two points the line passed under them by tunnels.

All material for this work was hauled by the rack-road, and the city was not allowed to begin construction, could not in fact, until the road had ceased operations for the summer. The contract with the company owning the road compelled the city to fully protect the track at all times, and, as a precautionary measure, the pipe was laid between the track and the creek, which made it necessary to cross under the rack-road at three points. The weather was very cold, but this proved to be a great help and saving in cost of construction, where the road was on embankment. At such places the pipe line came on embankment slopes, which were about 1 to 1, and were composed of disintegrated granite or gravel.

FIG. 5.—VIEW ON RUXTON CREEK PIPE LINE SHOWING TUNNEL UNDER BOULDERS.

FIG. 6.—VIEW ON RUXTON CREEK PIPE LINE SHOWING CURVE AT HALF-WAY HOUSE.

To excavate a bench on this slope of sufficient width for the pipe and at the same time preserve intact the track, was no easy work. In some places sheet piling was driven by hand to support the track side, a bench shoveled off, the pipe laid and the original surface restored with materials borrowed from the opposite side of the track. Generally, however, the track side of the trench was sprinkled with water from the creek near by and in freezing it supported the track in perfect shape.

A considerable portion of the roadbed was in excavation and here the pipe trenching was in solid granite and to excavate a trench at the end of the ties, of sufficient depth and preserve the track, was a more difficult task than the embankment work. This was done, though, and the crossings under the track blasted out without unbolting the rail joints, but it was tedious and costly.

At frequent intervals along the line and at all points where the pipe was on embankment and on the outer side of the curve of roadway, anchors were placed. These were made of steel, a draw band with two bolts around the pipe and a steel rod; one end having a forged eye to receive the bolt of draw band, the other turned at a right angle and placed in hole drilled in the granite walls where most convenient, and the remaining cavity filled with lead. The city blacksmiths made all these anchors and they were found to be cheap, simple and efficient.

Reservoir No. 2 (Beaver Creek system).—The next step was to complete the storage system of which reservoir No. 2 was the first work. It is located on Middle Beaver Creek one mile above the intake of the Beaver Creek pipe line already mentioned. The dam is 725 ft. long; maximum fill 30 ft., with top width and slopes of the standard dimensions previously given. The construction, however, differs from the other dams alluded to in some respects. Earth was a very scarce article, while granite boulders were plentiful, so the outer third was constructed entirely of granite boulders laid in by hand and faced with such earthy materials as were available.

Timber Line Flume.—To divert the waters of West Beaver Creek into Middle Beaver Creek it was necessary to resort to one of three methods: (1) A flume seven miles long; (2) a tunnel 6,400 ft. long, or (3) a pumping plant. For this last method the head in the pipe line could be utilized for generating electricity as a motor power. The tunnel was finally adopted, but for temporary supply a branch of West Beaver Creek was diverted by means of a flume 4,000 ft. long and carried over the divide through which the tunnel is now being driven. At that time it was not expected that the tunnel would be constructed for several years, but being suddenly confronted with a formidable rival in Cripple Creek, Victor and several other towns of this mining district which have a combined population of 30,000 people and are rapidly increasing in size, and further, the only practicable source from which they may receive a water supply being this same Beaver Creek, it was thought wise and proper to push forward as rapidly as possible the construction of Strickler Tunnel. The lumber used in this flume is Southern pine and the cost of transportation from Colorado Springs to the location (17 miles) exceeded the price paid for the lumber plus the freight from Texas.

Strickler Tunnel.—From the foregoing it will be seen that the construction of the Strickler Tunnel is simply to divert the waters from the western to the eastern slope of Pike's Peak. Fig. 1 shows the location of the tunnel in relation to other parts of the system. The total length of excavation is 6,427 ft., of which about 150 ft. at west end and 35 ft. at east end will be open cuts, leaving a net tunnel length between portals of 6,242 ft. The west portal and intake is located at the confluence of two branches of West Beaver Creek and the east portal at a point on Middle Beaver Creek, 1,200 ft. from and 500 ft. higher than reservoir No. 2 of the city's system. The grade elevation of the west end of tunnel is 11,540 ft. above sea level, and the gradient used is 0.50 ft. per 100 ft.

The line of the tunnel is a tangent, course N. 88° 40' E., and passes through the ridge or "hogback" connecting Pike's Peak and Big Horn Mountain. From the west portal, for a distance of 5,300 ft. the surface is a gradual ascent to the top of the ridge, which point is 424 ft. above grade, then dropping rapidly to the east portal which is on the face of a very nearly vertical cliff of red granite coarse and porphyritic. So far as surface indications determine the east 4,200 ft. is through this same formation, but the west 2,000 ft. shows morainal debris, and this portion of the tunnel will probably require timbering. Geologically speaking this ridge is the seat of an ancient glacier which divided at this point. One portion flowed westward and ploughed out the canyon through which West Beaver Creek now flows, another portion flowed southward, forming the valley of Middle Beaver Creek, and ending in a cul de sac near Seven Lakes, two miles below reservoir No. 2. The west portal is 1½ miles west from the summit of Pike's Peak and about four miles east from "Bull Hill" of Cripple Creek fame. The tunnel site is reached via the Manitou & Pike's Peak Ry. to Saddle House Station, from which point a wagon road has been constructed by the city for use in hauling materials for construction of the timber line flume and reservoirs Nos. 7 and 8. The site may also be reached via the Bear Creek Canyon Toll Road, a distance of 20 miles.

In calling for bids it was stated that it was desirable that the cross-section of the tunnel should be the smallest possible for economical construction. Two cross-sections were designed and bids received separately on each. Figs. 7 and 8 show these cross-sections, both in solid rock and where a timber lining is required. Proposals for the work were received from eight different firms, the prices ranging from $7.99 to $21.75 per ft. for tunnel excavation (Eng. News, Jan. 16). The price of Wilson & Jackson, Chicago, Ill., being $12.90 for tunnel excavation, and $4.76 for timbering, and also being for the cross-section 4 ft. × 7 ft. the least price it was adopted. The total cost, as figured from estimated quantities for comparison, is $99,916. The greater number of bids were the same for each cross-section, one firm, however, bid a less price for section Fig. 8 than for section Fig. 7, and this was undoubtedly correct. The cross-section 5 ft. × 6.5 ft. is the more economical one for the contractor. The amounts of excavation per lineal foot for the two sections are 0.94 cu. yd. in solid rock, and 1.9 cu. yd. in timbered excavation for Fig. 7, and 1 cu. yd. and 2.11 cu. yds., respectively, for Fig. 8.

As stated above, when deemed necessary by the engineer the tunnel will be timbered with red or yellow fir or yellow pine, which may be sawed or hewed as most desirable. The inside lines of any timbers must not fall within the prescribed limits of rock section. The sets of timber will be of 8 × 8 ins. or 10 × 10 ins. and placed 3 to 4 ft. apart as the character of materials supported require. Outside of the posts and arch blocks a 4-in. lagging will be placed and the whole set brought to a firm bearing by wedge-shaped keys. Any cavity existing between lagging and sides of tunnel will be filled with stone or timber as contractor may choose.

The foregoing gives the character of the tunnel work sufficiently well. The method of construction was left to the discretion of the contractor with the usual restrictions as to responsibility, safety, etc., and we have secured from the contractors, Wilson & Jackson, of Chicago, Ill., a brief description of their plant and of the system of excavation to be followed. Briefly stated, electricity, generated by water power, will operate an

air compressor plant to furnish power for the work.

The Ruxton Creek main, as already noted, extends from Manitou to a point ½ mile above the Half Way House on Pike's Peak. This pipe line has a fall of over 2,400 ft. without dips or summits and a section of the line will be used for power purposes, the primary plant being erected at Minnehaha Station. This plant consists of a 36-in., 220-HP. Pelton wheel which operates a 150-K-W. three-phase generator built by the General Electric Co. From this generator a 3,500 volt current is sent to the east portal of the tunnel, where a step-down transformer supplies a 220-volt current to the motor, which will be described further on. The transmission line consists of three No. 5 wires carried on cross-arm poles, and is provided with lightning arresters at intervals. Altogether the transmission line is nine miles long.

The plant at the east portal of the tunnel consists of a 75-HP. motor, driving a 75-HP. air-compressor, and smaller motors to drive a Sturtevant blower for ventilation, to run the blacksmith shop machinery and to light the tunnel, shop and yards. From the compressor, air will be piped into the tunnel from the east portal and also over the mountain by a 1½-mile 3-in. pipe to the west portal. Two drills will be worked at each end and the air will be also used for derricks and other power machinery.

For taking out the spoil, a trolley carrier system similar to the ones so much used in Chicago packing houses will be employed. A longitudinal timber will be fastened to the tunnel roof directly in the apex of the roof arch, and this timber will carry by means of hangers a steel bar trolley rail on which carriages or trolleys will run. Outside the portal this rail will form a loop so that the carriages can pass around and be taken back to the working face. Each trolley carries a steel pan of 1½ cu. ft. capacity so suspended that by means of a trip it is automatically dumped when it reaches the proper point. At the east end of the tunnel this dump is emptied directly into a deep gorge only a few feet away, and the dump at the west end is almost as favorable.

The contract for the tunnel was awarded Dec. 27, 1895, and shortly thereafter the contractors began erecting the necessary plant, which has only recently been put in operation. Work on the approaches to the tunnel is about completed.

Reservoirs Nos. 7 and 8.—The water from these two reservoirs, which are located on the west slope of the range, will pass through the Strickler tunnel. Both reservoirs are under construction and will be completed this year. The contractors are Ord & Swipe, of Colorado Springs, Colo. Fig. 9 is a cross-section of the dam for reservoir No. 8. This dam is 1,200 ft. long. Owing to scarcity of earth the outer portion of this dam is built of rock, as previously described for reservoir No. 2. Fig. 10 shows the cross-sections of the two dams for reservoir No. 7, which is the highest reservoir of the system, being at an elevation of 12,109 ft. above sea level.

Prospect Lake Reservoir.—There remains to be described only one other reservoir of the domestic supply system of Colorado Springs, viz., the Prospect Lake reservoir, located east of the city. This reservoir was built during the winter of 1890-'91. It is used principally for irrigation and resort purposes, but can be utilized for domestic supply for a considerable portion of the city if necessary. It is located on the opposite side of the town from the Mesa reservoirs already mentioned. The town lies between and on lower ground than either of the reservoirs, Mesa reservoir being 200 ft. and Prospect Lake 80 ft. above City Hall datum. This reservoir basin is a peculiar one. Located on the very summit of a sand mesa, the wind action has gradually ploughed out along the line of prevailing winds, northwest to southeast, a basin 2,800 ft. long, 1,200 ft. wide and 23 ft. maximum depth, leaving natural dams at either end, so that without any work at all it gave a capacity equal to the above dimensions. The engineers simply enlarged this piece of nature's handiwork by increasing the height of the dams, thus submerging the entire basin.

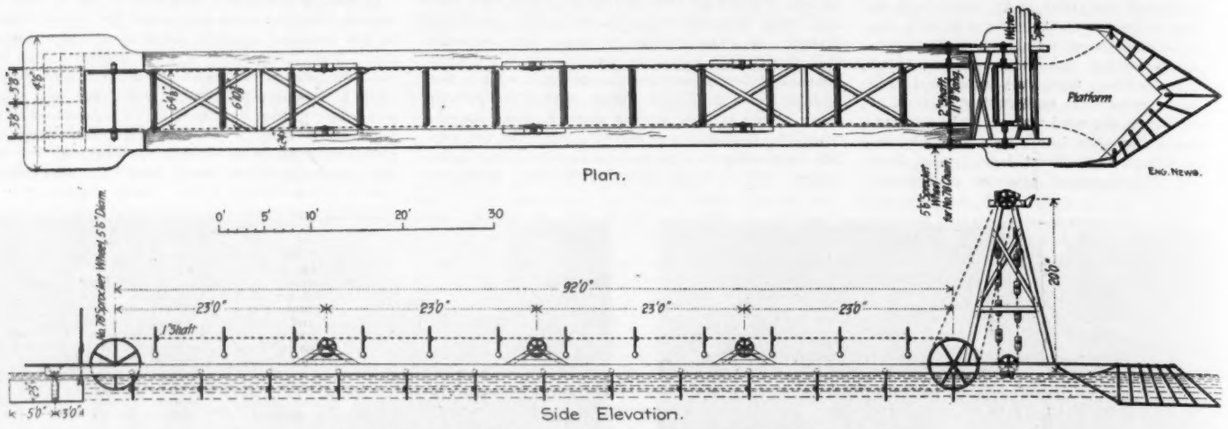
The northwest dam is 1,250 ft. long and 14 ft. deep. The southeast dam is 1,320 ft. long and 12 ft. deep. The slopes in each case are 3 to 1 and 2 to 1 for inner and outer slope, respectively, and the top width is 20 ft. The inner slopes are heavily riprapped with cobblestone. The northwest dam is built up of fine sand and probably 15% of sandy loam, which was moist from melting snow. The southeast dam was composed of fine sand only and was neither moist nor sprinkled. Each dam was constructed by the same parties and in the same manner, but the northwest dam was completed before the other was commenced. The northwest dam seeped considerably the first year, while the dry sand dam has not leaked at all. In order to drain the water from the bottom of this natural basin it was necessary to make an excavation 1,000 ft. long and 23 ft. deep at the greatest cut. A 12-in. supply main from the city system carries the overflow water into this reservoir, which pipe was laid on a slightly ascending grade from a point in the city to the reservoir, so that the pressure from the Mesa reservoir forces the water into Prospect Lake, but when the valve is closed, cutting off Mesa reservoir pressure, then the pressure due to the elevation of Prospect Lake forces the water back through the same main into town for irrigation purposes.

In the foregoing no mention has been made of irrigation reservoirs and pipe lines developed in connection with the domestic water supply system, nor have many of the details shown by the drawings been described. Several minor details to further improve the system will doubtless be developed later and it is quite possible that work may be begun in the near future to develop the water power, which has been made available by the various constructions. At present careful measurements are being made of the rain and snow fall, and all streams are being gaged with the intention of determining very closely just what can be expected in the way of precipitation and runoff of the available watershed.

As stated above the entire work has been designed and carried out by Mr. H. I. Reid, City Engineer, Colorado Springs, Colo. His assistants in all the work have been Messrs. Delos Durfee, E. W. Chase, and E. S. Gandy.

## A CURRENT MOTOR FOR PUMPING WATER.

The accompanying illustration shows an interesting machine which has recently been developed specially for the purpose of raising water for irrigating purposes, though it promises to be applicable in a variety of situations. It consists simply of a long narrow float or pontoon, carrying an endless chain to which are attached floats at intervals of about 8 ft., which receive the force of the current. The chain, or rather chains, for there are two which run side by side, carrying the floats between them, run over sprocket wheels at each end of the pontoon, and the wheels at the head transmit the power thus gained to an overhead shaft which lifts the water by an endless chain pump.




PLAN AND ELEVATION OF A CURRENT MOTOR FOR PUMPING WATER.
Designed and Built by the F. C. Austin Mfg. Co., Chicago, Ill.

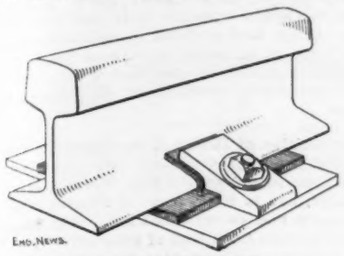
It will be evident that in a stream with a swift current a very considerable amount of power can be developed by this simple mechanism at very small expense. The system is especially applicable to the streams of the Far West where an unstable bed, or sudden and great floods makes the erection of permanent dams for the development of water-power almost impossible, and where the water often carries silt which would make the operation of almost any type of cylinder pump expensive.

Further, the apparatus is especially adapted to locations where the machinery must be as simple and light as possible on account of difficulties of transportation, and must be susceptible of repair with the crudest of tools. It will be seen that it can be made of any size desired to suit the location in which it is to be placed, the quantity of water desired, the height to which it is to be raised, etc. The apparatus is manufactured by the F. C. Austin Mfg. Co., of Chicago, Ill., a firm which has given special attention to the development of irrigation machinery, and to which we are indebted for the blue-print from which our cut is prepared.

THE SEWALL DYKE FOR LEVEE PROTECTION is being endorsed by the Sugar Planters' Association of Louisiana, and other citizens of that state. The system is that of H. F. and N. H. Sewall, and has been tested for about three years at New Orleans, Bayou Goula and the South Pass. The plan, says the New Orleans "Picayune," is to construct pile spur-dykes, at intervals along a caving bank, projecting up stream "at an angle of about 25°," with the piles driven 30 to 35 ft. into the river bottom. The conditions require piles up to 150 ft. in length and to meet this condition Messrs. Sewall have devised a special form of spliced or continuous pile. At New Orleans the river is 50 ft. deep and the dykes run out about 135 ft., but they have stood the high water of three years. The dyke at Bayou Goula was built in 1894 and terminates in water 115 ft. deep; but has well answered its purpose. The Planters' Association will ask that Congress take this matter in hand directly.

## INSULATING RAILS FROM METAL TIES AND BRIDGE FLOORS.

On roads using a track circuit for signal operations and having the rails laid upon metal ties or upon the metal floors of solid floor bridges, it is necessary to provide some efficient means for insulating the rail from its metal supports. We illustrate herewith a method of insulation which is in use on the new Park Ave. viaduct and Harlem River drawbridge of the New York Central R. R., where (as has been described in our columns) the rails are bolted directly to the rectangular transverse




Device for Insulating Rails.

troughs which form the floor. The construction was shown in our issue of May 7, 1896, in an article on "Short Span Bridges." There are three pieces of indurated fiber. One forms a bed plate, and has slots for the edges of the two shorter pieces which fit between the rail and the bolted clamps by which the rail is secured to the metal structure or tie. The same device may be applied to wooden ties when desired, substituting two screw spikes for the bolts in the clamps. The patents are owned by the New York Rail Insulation & Equipment Co., 200 Market St., Newark, N. J.

## BASIC STEEL RAILS.

The use of basic steel rails having a year or two ago been prohibited on the Austrian State Railways, Prof. Tetmajer, of the Polytechnic School of Zurich, Switzerland, published a paper in which he defended the use of such rails. The action of the Austrian government was due largely to two lots of inferior rails having been furnished by a German company. On the representation of the officers of a large basic Bessemer steel plant the government appointed a commission to investigate the matter (the firm referred to selecting two members), and as a result of this investigation the order was reversed, although basic rails are still required to show a tensile strength of 71,100 lbs. per sq. in., while for ordinary Bessemer rails a tensile strength of only 66,800 lbs. is required.

The defective basic steel rails above referred to were accepted in spite of a low tensile strength, as the rails were needed at once, but after some time defects appeared in the shape of longitudinal splits in the rail heads, sometimes extending nearly the entire length of the rail, a little to one side of the center line, and in some places this split was large and gaping. As the splits did not extend to within a few millimeters of the surface of the head they only became evident after the rails had been worn to some extent. Out of 1,540 tons of these rails furnished and laid in 1890, 122 rails, or nearly 8%, had been removed by the end of 1893. These same defects appeared to a still greater extent in the second lot of rails furnished by the same company, and careful examination showed that the defect existed originally in the steel. The split was not vertical, but followed irregularly the contour of the rail, and its walls showed plain signs of oxidation. In some exceptional cases the ends of the rails were crushed, owing to the softness of the material, but no cross fractures occurred, though such fractures are not uncommon in ordinary Bessemer steel. Defective rails that were tested showed a tensile strength of 62,000 lbs., with 28.3% elongation for the base, and 68,000 lbs., with 24.8% elongation for the web. The specifications required not more than 0.6% manganese and 0.1% each of phosphorus and sulphur, but analyses showed 0.415 to 0.695% manganese and 0.128 to 0.221% phosphorus.

That the rails successfully passed the drop and bending tests is explained by the low percentage of carbon and the absence of silicon, as such rails, even with too much phosphorus, may give good results in these tests and show no transverse fracture. The presence of the longitudinal split following more or less regularly the contour of the section on one side of the rail is due to careless work with the ingots. Blowholes are naturally found disposed symmetrically at a certain distance below the surface of the ingot, and if such an ingot is removed from the mold before the metal has thoroughly set, and is laid on its side on the floor or on a car, the soft interior metal will settle down to the lower side, filling the blowholes on that side, but enlarging those on the upper side, and these latter will form the splits when the ingot is rolled. Unsatisfactory and unreliable results may occur through carelessness in the blowing of the steel, as well as in the casting and handling of the ingots, but Prof. Tetmajer pointed out that it does not follow that the basic Bessemer process should, therefore, be condemned. In well managed works the heats are blown regularly, the phosphorus is brought down below the specified limit and the ingots are not removed until the metal has thoroughly set.

Since 1878 the basic process has developed rapidly. In 1880 only 50,000 tons were made, while in 1893 the output was 3,638,556 metric tons, of which about 20 to 25% was made by the basic open-hearth process. The metal is said to meet with a steadily increasing application in the construction of bridges and railways all over the continent of Europe and in England. As one of the principal objections made to basic steel has been the alleged irregularity of its composition, Prof. Tetmajer gave in his paper a number of analyses showing that great regularity is actually obtained in the output of many large works and referred to the value of the Darby and Meyer recarburization process in this connection, and also states that the basic Bessemer boiler plates of the Peine works compete successfully with the best brands of Siemens-Martin steel.

In Switzerland the principal railways use from 19 to 44% of basic rails, while some secondary railways use basic rails exclusively and others use acid Bessemer rails only. No restrictions are made as to manufacture, but the specifications require that the rails shall be faultless, made from perfectly sound ingots, whose cross sectional area is 20 times that of the rail, and that they must stand cold bending, tensile and chemical tests. Crop ends are usually chosen for the drop and bending tests, while test bars 1 in. diameter are cut from the rail heads for tensile tests. The tensile strength is required by the new Swiss specifications to be 5.5 tons per sq. cm. (about 81,000 lbs. per sq. in.) and the product of this figure and the elongation must be at least 90, which is called the "coefficient of quality." For cold bending a 4-ft. piece of rail is laid on supports 3 ft. 3⅝ ins. apart and must carry for ten minutes without permanent deflection a center load in tons of 0.15 W (W being the moment of resistance of the piece in centimeters), and must also carry a load of 0.25 W without breaking, the permanent deflection in this case being carefully noted. The average chemical composition required is not less than 0.3% carbon, not more than 0.3% silicon, and not more than 0.1% each of phosphorus and sulphur, the proportion of manganese being left to the discretion of the manufacturer. On the Northeastern Railway, of Switzerland, 27,044 basic Bessemer rails were laid between 1885 and 1893, of which 14 were removed (5 for being split, 5 for being crushed, 2 for being broken and 2 for ordinary wear and damage), giving a proportion of 0.518%. Between 1875 and 1893 the same road had laid 134,902 acid Bessemer rails, of which 431 had to be removed (216 broken, 83 split, 54 crushed and 78 worn and damaged), or 0.3195%. It is stated, however, that in the earlier years the rail flanges were notched in some places, which may have increased the percentage of removals of the acid Bessemer rails.

In dealing with the manufacture of basic rails in Germany it was pointed out that the rails from the only two works using the basic Bessemer process show the greatest resistance to wear. Thus the decrease in height of rail per million tons of traffic was 0.005 and 0.018 mm. (or 0.0002 and 0.007-in.) respectively, while the Krupp acid Bessemer rails come third with 0.025 mm. (or 0.00098-in.). This wear is obtained by dividing the decrease in height of the rail by the amount of tonnage in million tons passed over it during the period of observation. Returns from the state railways of Finland and Hungary showed that the wearing quality of basic Bessemer rails is above the general average, in some cases showing a decided superiority. The renewals of defective rails are also less than with acid rails. From the information collected, Prof. Tetmajer concluded that basic Bessemer rail steel can be made with great regularity in its composition and free from oxygen and red shortness, and also that by the application of the Darby and Meyer recarburization processes any grade of hardness can be easily and regularly obtained.

## LEGAL DECISIONS OF INTEREST TO ENGINEERS.

### When Punitive Damages Will Not be Allowed.

In the absence of evidence, in a personal damage suit against a coal company, of malice or reckless conduct on the part of the company indicating a purpose to have the employee injured, or of a reckless disregard of the safety of the person of the employee the injury should be confined, in case it returns, a verdict against the company, to compensatory damages only.—McHenry Coal Co. v. Sneddon (Ct. App. of Ky.) 34 S. W. Rep., 228.

### Assessment Lien, Contract Must Comply with Statute.

A contract reciting that a party would construct curbing and gutter ways in accordance with the specifications thereto annexed, but to which no specifications were annexed, is not a sufficient compliance with a statute requiring all contracts to be in writing and signed by the contractor; and under it no lien can be fixed, against the will of the owner, upon abutting property. A proceeding to charge one with improvements for which he has not contracted must show a strict compliance with the law. —Schwiesau v. Mahon (Supr. Ct. of Cal.) 42 Pac. Rep., 1065.

### Railway Bridge and Drainage Construction.

A railroad company's property may be benefited by the drainage afforded its right of way, and at the same time may be damaged by a requirement to remove or alter the construction of its bridge across the proposed drain. If the cost of temporary changes in a railroad bridge to admit of improvements to a stream for drainage purposes do not arise from the railroad company's continuing duty to so maintain its bridge as to admit public rights accruing subsequent to the construction of the bridge, such changes are proper subjects of consideration in the ditch proceedings, and the costs of such changes should be deducted from the assessment of benefits to the company.—Lake Erie & Western Ry. Co. v. Cluggish, drainage comr. (Supr. Ct. of Ind.) 42 N. E. Rep., 743.

### Engineer's Estimate, When Not Conclusive.

The provision in a construction contract that, when the work is completed, there shall be a final estimate made by the engineer of the quantity, character and value of the work, agreeably to the terms of the contract, and the balance, after deducting monthly payments, and on the contractor giving a release, will be paid in full, is not an agreement that the engineer's estimate shall be conclusive.—Central Trust Co. v. L., St. L. & T. Ry. Co. (U. S. Cir. Ct. of Ky.) 70 Fed. Rep., 282.

### Discretion of Court as to Admission of Engineer's Opinion.

The refusal of the lower court to permit a witness who has testified that he is a professor of civil engineering, and has made the law of moving bodies a study, and can tell how far a train will move by its momentum, to testify as an expert as to the distance such train would travel, in order to contravene the testimony of other witnesses testifying from practical experience, will not be disturbed on appeal.—Blue v. Aberdeen & West End Ry. Co. (Supr. Ct. of N. C.), 23 S. E. Rep., 275.

### Liability of Trolley Company for Injuries.

In an action against a street railway company it appeared that in passing a switch at the top of an incline, the trolley had to be adjusted from the rear of the car; that there was but one person in charge of the car, whose position was in front, and that he, without stopping the car, went to the rear end, adjusted the trolley, and got off to run ahead to the front end; and that while running he fell, and was unable to overtake the car, which finally jumped the track and killed a passenger. The Supreme Court of California held that the company was liable. —Redfield v. Oakland Consol. St. Ry. Co., 42 Pac. Rep., 822.

### Use of Streets by Gas Company.

A gas company was granted by ordinance the privilege of laying pipes in the streets of a city, subject to the conditions of a prior general ordinance fixing the conditions generally on which corporations could lay pipes, and requiring any such corporation to file with the comptroller a certified copy of a resolution of its board of directors accepting all such conditions. A company filed with such officer a resolution of its directors agreeing to comply with the general ordinance "excepting so far as any of its terms may be held or adjudged illegal or unreasonable by the courts." The court held that the council of said city never having consented to such modification of the acceptance, and the company having enjoyed the privileges of the ordinance under its acceptance, it could not refuse to comply with certain conditions of the ordinance on the ground that after its acceptance they were decided to be illegal.—Allegheny v. Peoples' Nat Gas & Pipage Co. (Supr. Ct. of Penn.) 33 At. Rep., 704.

# ENGINEERING NEWS
AND
## AMERICAN RAILWAY JOURNAL.

*Published every Thursday at Tribune Building, New York. Entered at the Post Office, New York, as Second Class Matter.*

D. McN. Stauffer, Charles Whiting Baker.....Editors.
Wm. Kent, E. E. R. Tratman, M. N. Baker, Chas. S. Hill, A. B. Gilbert.....Associate Editors.
Chas. W. Reinhardt.....Chief Draftsman.

Geo. H. Frost, P. P. Burt.....Business Managers.
Alfred E. Kornfeld, New York; F. A. Peckham, Chicago.....Advertising Representatives.

Publication Office.....Tribune Building, New York.
Chicago Office.....1636 The Monadnock.
London Agencies: Kegan Paul, Trench, Trubner & Co. (Limited), Paternoster House, Charing Cross Road; Sampson Low, Marston & Co., (Limited), St. Dunstan's House, Fetter Lane.

*SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00; Single copies, 15 cents. To all other countries in the Postal Union, add $2.08 per annum (4 cents per number) to above prices for postage. No club rates allowed. Mailing addresses may be changed at will by sending both old and new address. We shall be obliged if subscribers who fail to receive their papers promptly will notify us without delay. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 326 means that subscription is paid to the 32d week (that is the issue of Aug 6) of the year 1896; the change of these figures is the only receipt sent, unless by special request.*

*ADVERTISING RATES: 20 cents per line agate measure. Want notices, special rates, see page 22. Rates for standing advertisements sent on request. Changes to standing advertisements must be in hand on Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.*


We illustrate and describe on another page of this issue a structure recently completed which is entitled to rank as one of the great bridges of the world, a cantilever structure over the Danube at Cernavoda, Austria, with a central span of 623 ft. The bridge is of more interest to American engineers, however, by reason of some interesting features in its design. The main trusses at the piers have a total height of 105 ft., and they are inclined toward each other, so that while they are 29 ft. apart at the base they are only 10 ft. 6 ins. apart at the top. Of course previous cantilever bridges have made use of inclined trusses; but it is worth considering whether the idea might not be adopted to advantage in the design of curved chord trusses of every long span.

A still more curious and, so far as we recall an entirely novel feature, is that the width of the cantilevers is greater at the piers than at their ends. The distance between the truss centers at the floor level being 29 ft. at the piers and only 21 ft. at the ends of the cantilevers.

Another notable feature in connection with the Cernavoda bridge is the fact that the main cantilevers were completed before their supporting piers were built, and were raised by hydraulic jacks as the piers were built up. While this may seem an awkward way to carry on work, its advantages in the saving of false-work and risk in erection are evident; and it will be remembered that European engineers have not had the experience in bridge erection over great rivers that we have had in this country, and are presumably willing to go to greater lengths to avoid difficulties in such work.

Our recent comments (in connection with the Atlantic City collision) on the need of installing derailing switches interlocked with the signals at every grade crossing of steam railway lines, have additional force furnished them by a recent accident, unimportant, so far as casualties are concerned, at Danville, Ill. The particulars, as furnished by a correspondent, were as follows: At Danville Junction the Peoria Division of the Cleveland, Cincinnati, Chicago & St. Louis Ry. (better known as the "Big Four") crosses the Wabash R. R. at grade. On Aug. 3 a caboose and four cars of a freight train on the former road were left east of the crossing and ran back down the grade and struck a Wabash freight train which was passing over the crossing, striking about four cars back of the engine. Nine cars were wrecked, but as no trainmen were on them no one was injured. Here is an occurrence which admirably illustrates the fact that a signal system for the protection of a grade crossing cannot be called safe unless some mechanical means of protecting a train using the crossing from trains on the other track is provided. Runaway cars do not obey danger signals, and the much-vaunted appliances for automatically setting the brakes of trains running past a danger signal would have no effect on them. In the case of this Danville accident, it was pure chance that it was not a crowded excursion train which these runaway cars struck instead of a freight train. Had that occurred there would have been a repetition of the Atlantic City horror, and a new demand on the part of the public for the abolition or better protection of grade crossings. Because no one was hurt in this Danville accident the public pays no attention to it, but to a railway officer it should be as instructive as if the dead and injured resulting from it had been numbered by scores.

What may be termed the itinerary investigating committee, especially in connection with the development of public works, is a subject which might be discussed to advantage by students of municipal government and one which directly concerns many engineers and contractors. To come directly to the point with a concrete illustration, a supplementary water supply for the fire protection of Boston, consisting of independent fire mains supplied by powerful engines with water from the harbor, has been under discussion for some years. It is now proposed to have three aldermen and five councilmen, composing the Joint Standing Committee on Fire Department, make a trip to New York, Brooklyn, Philadelphia, Baltimore, Washington, Richmond, Pittsburg, Cincinnati, Cleveland, Buffalo, Detroit, Chicago, Milwaukee and Niagara Falls to study this question, together, it is said, with training schools and veterinary hospitals for fire department horses. It is proposed to invite a representative of the city engineering department to join the expedition. The Boston "Herald," in a brief editorial headed "Eight to One," calls attention to the fact that the investigation will be made by "eight politicians and one expert," as it terms those who are to take part in it, and asks if it might not be well to reverse the numbers.

We know nothing whatever of the character or qualifications of either the "eight" or the "one." We are sure that one capable engineer is all that is needed, ordinarily, for a trip of this sort. Whether eight city fathers are necessary depends altogether upon the point of view from which the matter is considered. Looked at technically, we have no hesitation in saying that one engineer without the other members of the party could learn all that was valuable on the subject in hand, weigh the evidence and recommend a plan best suited to the needs of the city. On the other hand, the practical aspects of city legislation, as now conducted, show that it is one thing to scientifically determine the best mode of procedure and quite another to secure the passage of the necessary legislation. "Seeing is believing," and in the case of the proposed introduction of some public works new to the locality, like brick or asphalt paving, or a garbage disposal plant, the committee having the matter in charge may come back satisfied from an inspection of successful works of the same character in other cities and ready to recommend the adoption of what some or all of them might otherwise think a doubtful experiment, at best, while the confidence of the committee will carry its recommendation through the city council. With good engineering advisers, and proper confidence in them, in many cases where investigating committees have gone out all this would be unnecessary. Often the engineering department possesses all the information needed to decide on the best plan and to carry it out, and where it does not the department could obtain it at much less expense than would be incurred by three or five or a dozen men in their journeyings over the country. As human nature stands however, it is far easier to secure a large appropriation for such a trip than a small one to conduct engineering investigations. There is much more that might be said on all the various phases of this subject, especially regarding the educative values of these itineraries on the one hand, and on the other hand their superficial character in many cases, their cost, and their occasional dark and devious ways. But it is gratifying to note that there seems to be an increasing tendency to at least take an engineer along, thus profiting by his knowledge and experience as he points out salient features, and sometimes gaining through him for the city valuable information which would otherwise be overlooked.

The decision of Justice Edwards, in the case of the Hilton Bridge Company, New York, vs. the State Superintendent of Public Works, George W. Aldridge, has in it elements of interest to bridge companies and to state officials. The company named applied for a writ of mandamus to compel Mr. Aldridge to award to it the contract for two lift-bridges over the Erie Canal, in Utica. The bridge company claimed that the work was awarded to a lower bidder owing to the fact that certain alterations were made in the successful company's proposal after the bids were opened. This action, the attorney of the bridge company claimed, was illegal and contrary to Section 132, Chapter 338, of the Laws of 1895, which requires that all bids shall be definite and certain, and that no bid which is not definitely certain "shall be received or acted upon." The attorney claims that two items were uncertain in the bid of the successful company and the proposal was only made definite after communicating with this company after the bids were opened. In a short opinion issued, Justice Edwards practically says that the provision of the constitution quoted does not apply to contracts let by the Superintendent of Public Works. He holds that that official is vested with great discretionary powers in awarding contracts and that his action in this matter was perfectly just.

Without knowing more than we do of the actual facts of the case the opinion of Justice Edwards can not be criticised. But it is interesting to know that the State Superintendent of Public Works, of New York, is vested with this unusual power and is not bound by the Constitution of the State. In his hands an award under similar conditions is doubtless safe; but the practice is not a safe one to extend to every official who is to pass judgment upon the character and status of a proposal. To permit any alterations in proposals once unsealed is to at once remove about the only safeguard remaining to the bidder; and while it might sometimes work an injustice to reject all explanation of unintentional blunders in a proposal, that amounts to a change in item prices, this seems to be the only just course to pursue. The law of the state is a wise one and should apply to all alike. The remedy is always left of rejecting all bids and readvertising, thus throwing all bidders back upon a common level.

For the last twenty years the engineers and manufacturers of Europe have been attempting to unite upon uniform methods of testing structural materials with regard to their mechanical properties, and conventions have been already held for this purpose at Munich, Dresden, Berlin and Vienna, attended by representatives of the technical professions. As might be expected in gatherings of this character, opinions differed widely, and while some agreement has been reached, many of the more important problems have yet to be solved, or present solutions revised. Under the existing conditions of trade intercourse any unification of testing methods will have little value unless it be adopted by all manufacturing countries, and hence every effort is, and should be made to secure the views and experience of the greatest number of delegates possible from technical associations and societies. At the last confer-

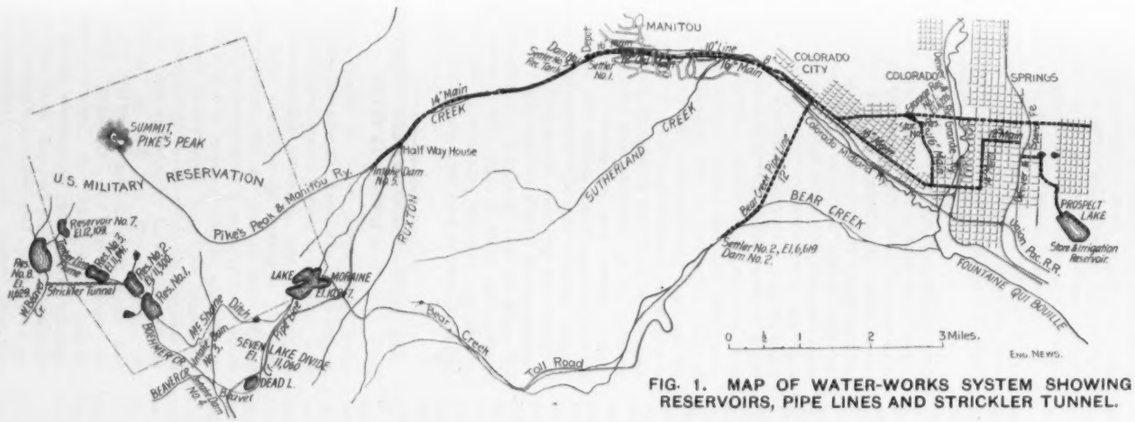



FIG. 1. MAP OF WATER-WORKS SYSTEM SHOWING RESERVOIRS, PIPE LINES AND STRICKLER TUNNEL.

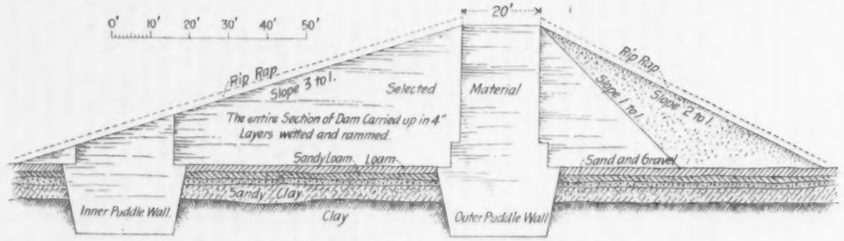



FIG. 3. CROSS SECTION OF LAKE MORAINE RESERVOIR DAM.

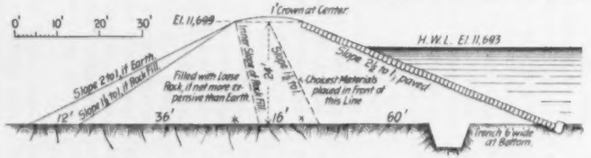

0' 10' 20' 30'
El. 11,699
1' Crown at Center
H.W.L. El. 11,693
Slope 2 to 1, of Earth
12" Slope 1½ to 1, of Rock Fill
Filled with Loose Rock, if not more expensive than Earth
Inner Slope of Rock Fill
Slope 1½ to 1
Slope 2½ to 1, Paved
Choicest Materials placed in front of this Line
36'
16'
60'
Trench 6' wide at Bottom.

FIG. 9. CROSS SECTION OF DAM, STORAGE RESERVOIR No. 8.

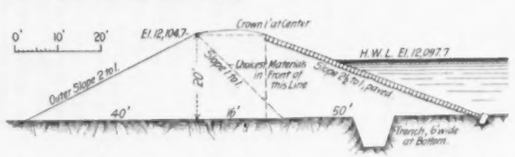



FIG. 10. CROSS SECTION OF DAM, STORAGE RESERVOIR No. 7.

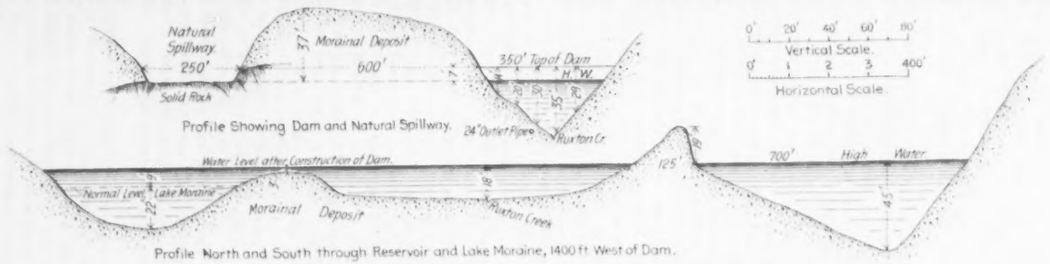



FIG. 2. TRANSVERSE SECTIONS OF LAKE MORAINE RESERVOIR BASINS.

## THE WATER SUPPLY SYSTEM OF COLORADO SPRINGS, COL.

H. I. Reid, City Engineer.

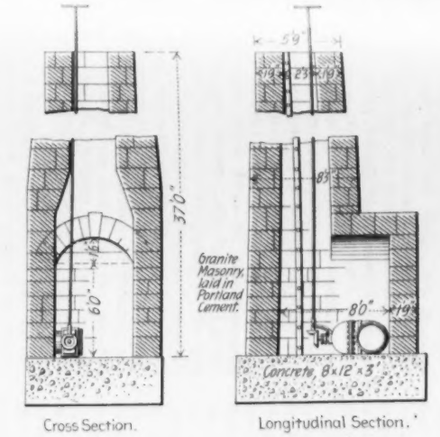



FIG. 4. DETAILS OF VALVE CHAMBER, LAKE MORAINE RESERVOIR.

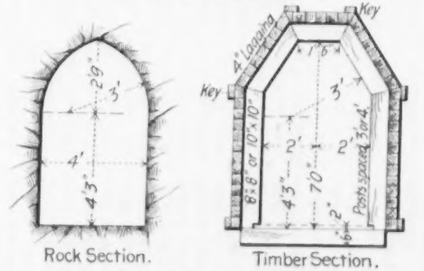



FIG. 7. ADOPTED CROSS SECTIONS OF STRICKLER TUNNEL.

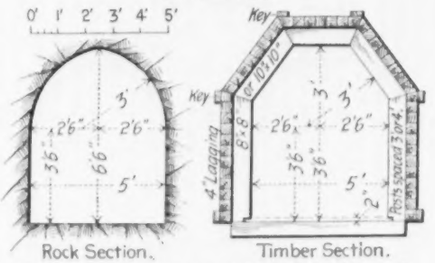



FIG. 8. ALTERNATIVE CROSS SECTIONS OF STRICKLER TUNNEL.

ence delegates attended from Germany, Austria-Hungary, Switzerland, Russia, France, America, Norway, Holland, Italy and Spain, but England was conspicuous by her absence. France, in 1891, created a government commission, having for its object the same as that of the permanent committees appointed at the later conventions, with the added advantage of more readily obtaining the funds needed for experimental research. The promoters of this unification in testing methods rely mainly, however, upon the international character of these conventions and believe that ultimate success can only result from all manufacturing nations uniting upon common standards and methods in the tests of structural materials. To this end they invite the technical representatives of all countries, and that new delegates may better understand the scope of the work proposed and that performed, Prof. J. Bauschinger, of Munich, has published the resolutions passed at the conventions held at Munich, Dresden, Berlin and Vienna, together with a short statement of the reasons for their adoption. This publication has been translated into English by Capt. O. M. Carter, Corps of Engineers, U. S. A., and by E. A. Gieseler, U. S. Assistant Engineer. This translation is issued from the Government Printing Office, at Washington, and can be secured by application. The resolutions referred to cover, in part, the tests of wrought iron and steel, copper, bronze and other metals, tests of wood, stone, paving and ballast materials and hydraulic binding materials. Aside from the great importance of a unification in the methods of tests, the text of this little book is valuable to all engineers as indicating the direction and scope of modern research in this connection.

With a full appreciation of the value of the work proposed at these conventions, it must be admitted that the task set is one difficult of performance, and some time will yet undoubtedly elapse before a thoroughly acceptable and international system of tests of structural materials can be adopted. This end will only come when the best and most experienced engineers of every country can meet in convention, discuss experiences and methods and, aided by special experimental research under standing committees, arrive at a common and intelligent agreement upon the problems presented. The difficulty lies in gathering men of this character together and enlisting them in the common cause. The views of isolated experts have little weight in a crusade of this type; what these conventions aim at is a concensus of the opinions of the technical professions and trades everywhere, and by this means alone can the nations unite upon any common methods of tests. Hence, it is important that every man who has valuable experience in these matters should be represented by communication or in person; and the wider the interest taken in the aims of these conventions the sooner will thoroughly valuable results be given out to all industries and to the technical professions.

## AN OPPORTUNITY FOR AN AMERICAN STEEL RAIL PLANT IN AUSTRALIA.

In recent issues we have discussed at some length the prospects for the extension of the export trade of the United States, which is a matter now receiving considerable attention, and bids fair to lead to very considerable changes in our commercial system, but an opening now offered for American business is in a somewhat different line. There is at this present time an opportunity open for some enterprising American capitalists and rail manufacturers to establish themselves in Australia, this opportunity being afforded by the invitation to bid for the contract to manufacture 150,000 tons of steel rails and other track material in the colony of New South Wales, as has been advertised and briefly commented upon in our columns. So far, all the track material for the railways of that colony (which are owned and operated by the colonial government) has been obtained from Europe, and mainly, if not entirely, from England, but the government is desirous of establishing home industries and developing native resources, and for this reason it has taken the initiatory steps toward securing the installation of a complete rail manufacturing plant. In extending this opportunity to American investors and manufacturers the railway authorities have, no doubt, been influenced by the excellent results which have followed the adoption of certain American details of railway practice, and the introduction of American types of locomotives, cars, brakes, etc.

Some considerable time will probably be required for the perfecting of negotiations and financial arrangements among men here who may contemplate entering the competition for the contract, and it will also be necessary to collect a large amount of information upon which to base the preparation of a safe proposal, especially as the bids are to state the prices per ton for rails delivered. The advertisements were first published in July, and the proposals will be received until Dec. 30 by the Secretary for Public Works, at Sydney, and by the Agent-General for New South Wales, in London. There should, therefore, be ample time to make all preliminary arrangements and to send engineers out to make personal investigations as to questions of character, cost and supply of ore, fuel, etc.; available sites, and their distance from the mines and railways; transportation facilities; extent of present iron working industries, cost of machinery, labor conditions, etc. The probability of further contracts for rails, the prospect for undertaking the rolling of structural iron work, etc., and the possibility of securing orders from the other Australian colonies, are also points to be considered.

The contract stipulates that the rails and other materials are to be manufactured in the colony, using native iron ore and other necessary minerals, and native coal, coke or other fuel, all raised and smelted in the colony. The delivery of rails is to commence within 18 months after the contract is signed, and is to be at the rate of 15,000 tons per annum for ten years, reckoned from the date of the first delivery. The other materials are to be delivered in quantities corresponding with the requirements of the track for which the rails are supplied. The total amount of material contracted for will be as follows: Steel rails, 150,000 tons; steel splice bars, 7 per cent. of the total weight of rails supplied (10,500 tons); steel track bolts, 7 per cent. of the total weight of rails supplied (10,500 tons); steel spikes, 6,000 tons.

The bids submitted must state the prices per ton for rails and other material delivered at the railway station most convenient to the works, and must be accompanied by a deposit of £5,000 ($25,000), the deposit of the successful bidder being retained by the government until the works have been completed and the delivery of rails commenced, and being forfeited if the bidder does not execute the contract within 30 days of his bid being accepted by the Minister of Public Works. All the work is to be done under the supervision of the Engineer-in-Chief for Railway Construction, and in accordance with drawings and specifications prepared by him, which accompany the contract, but are subject to change as to dimensions and weights required. The men are to be paid their wages at least once a month in current coin of the colony, the truck system or any other such system of payment by tickets for provisions, etc., being strictly forbidden. It is also provided that in the event of any failure on the part of the contractor to pay the claims of any tradesmen, workmen or laborers in full in current coin of the colony, the Minister of Public Works or the Engineer may pay the amount of the claim and deduct the same from any money due or becoming due to the contractor. The labor element has become very prominent and powerful in the colony, and it will be seen that ample care has been taken by the government to protect the men employed in the proposed rail works. The contract must not be assigned or sublet by the successful bidder. Progress payments may be made to the contractor monthly, in the proportion of 85 per cent. of the value of the material turned out.

In the early days of the New South Wales Government Railways, the English type of track was largely used, with 75-lb. double-head rails supported in heavy cast-iron chairs. The American type of track, however, with T-rails laid directly upon the ties, has been found far more satisfactory, and the contract above noted includes only T-rails of 60 and 80-lbs. per yd., but it is stated that the length is to be 30 or 40 ft., as required. The designs of the rails and angle bars show the influence of American practice, but the rail heads are open to criticism in the roundness of the tops (10-ins. top radius and ⅜-in. corner radius), while the splice bars are thick in the web but have a very narrow edge to the flange, and are evidently designed after the Pennsylvania R. R. section. In English practice, joints with short splice bars and four bolts are practically universal, but for this Australian track six-bolt joints are to be used, and will be an innovation. The bolts will be spaced uniformly 5 ins. c. to c. in angle bars 31 ins. long, this arrangement being in accordance with the tendency of the best modern American practice to use six bolts in short bars. It would seem from the specifications that the rails are to be secured to the ties simply by round spikes, ¾ and ⅞-in. diameter and 4¼ and 5 ins. long under the head. No other form of fastening is referred to, and we are inclined to look upon this as a weak point in the track construction, although the arrangement will be superior to the average American practice in that the spikes are round and driven into holes bored in the ties, while the heads are much heavier than those of our spikes. For the 60-lb. rails the bolts are ¾-in. diameter, and the bolt holes are 1 in. diameter in the rail and 13-16 × 1 1-16-in. in the splice bars. For the 80-lb. rails the bolts are ⅞-in. diameter, and the bolt holes are 1⅛ in. diameter in the rail and 15-16 × 1 3-16-in. in the splice bars. The bolts have the Whitworth thread and are fitted with hexagon nuts, no washers or nutlocks being used, or, at least, not shown on the drawings.

Some notes from the specifications may be of interest in this connection. The ingots from which the rails are to be rolled must be cast from a mixture of the best New South Wales hematite and charcoal spiegeleisen, and the chemical composition of the ingots is to be limited as follows: Silicon, 0.1 to 0.15 per cent.; manganese, 0.8 to 1 per cent.; sulphur not to exceed 0.069 per cent.; phosphorus not to exceed 0.06 per cent.; carbon to be from 0.43 to 0.57 per cent. in 60-lb. rails and 0.55 to 0.65 per cent. in 80-lb. rails. The carbon percentage is higher than has been usual in English practice, and the ores would seem to be low in phosphorus. The proportions may be varied by the engineer in accordance with the results of the inspection of the blooms and rails during manufacture and the tests of the finished rails, so as to secure the most suitable chemical composition. According to the specifications the engineer is given considerable power to harass the contractor in this matter of chemical composition, but unless he is an expert in rail manufacture we imagine that he will be slow to interfere to any great extent if the contractor shows that he understands his business and turns out good rails. Rails that require much cold straightening will not be accepted, and all straightening must be done without hammering. Each rail must be stamped at the end to show from which cast of metal it was made. Certain rails from each day's output will be selected for test, and from each of these will be cut a piece 4 ft. 6 ins. long; this piece being placed head upwards upon iron supports 3 ft. 6 ins. apart. The test piece must withstand two blows from a weight of 1 ton falling 6 ft., the deflection to be not less than 3¾ ins. or more than 4¼ ins.; it must then sustain one blow of the weight falling 12 ft. without fracture. The engineer may change the tests, the main object being to get rails of the highest quality in regard to strength and toughness.

The splice bars call for a higher grade of steel than is common in this country, being required to be made from steel of the same mixture and same chemical composition as the rails, while in this country the bars are usually of a softer steel (with lower carbon percentage) than that of the rails. In this particular detail American practice is mainly inferior to foreign practice. The bars are to be sheared or sawed to length, pressed between dies while hot to take out any bulge, annealed and punched. The splice bolts and the spikes are to be of mild steel, and the bars from which they are made are to stand doubling cold without fracture.

One point of particular importance to the colony will be the relation of the prices for rails as submitted by the bidders for this contract, to those now paid for imported rails, including the cost of freight for the latter. It was stated in the colonial legislature, however, in answer to a question on this point, that there was every reason to believe that bids would be submitted showing that rails could be manufactured at as low a rate as they could be imported. The present price of rails in England is £4 10s. to £4 15s. (say $22.50 to $23.75) per ton, and the freight rates from London to Sydney are 12s. 6d. to 15s. (say $3 to $3.75) per ton. The cost of English rails delivered would, therefore, be about $23.50 to $27.50 per ton. As to wages, we are informed that laborers are paid 18 to 25 cts. per hour, and mechanics about 30 cts. per hour. New South Wales, it may be noted, is practically a free trade colony. The iron deposits have not been worked very extensively, but coal mining is an important industry for home consumption and for export (some of the coal being exported to the United States), and there are large coking plants in operation. There are, we understand, no iron works of any extent now in operation, the field being practically open for the new works to get a good hold of the general iron and steel manufacture.

This is the first time, we believe, that a public invitation has been given for competitive bids for the establishment of manufacturing plants in foreign countries by American capital, but such plants have in some cases been established as the result of private negotiations, the latest and most notable example of this being the new locomotive works for the Russian government at Nijni-Novgorod, which, as noted in a recent issue, are to be designed, equipped and managed by American engineers and American manufacturers. This has undoubtedly resulted from the great success which has attended the extensive introduction of American locomotives into that country. The same reasons have probably had an influence in leading the government of New South Wales to offer to American investors and manufacturers the present opportunity to establish a steel plant and rail mill, and we trust that the matter will be taken up here, and that it may prove to be practicable and mutually profitable for American capital to undertake this enterprise.

## LETTERS TO THE EDITOR.

### Steel Makers and Chemistry.

Sir: The voluntary introduction of chemical limitations in the revised specification of the Association of American Steel Manufacturers, marks an advance that should not be passed without notice, and the argument that such limitations are valuable and necessary is doubtless nearing a close.

Arguments as to what the chemical limitations should be will now, as heretofore, be in order, and it is to be hoped that engineers will give the matter the attention which it deserves.

The eminent authority on steel, Mr. Wm. Metcalf, in his new book, "Steel," calls the impurities of steel "elements of disintegration," and brings out clearly how, when in sufficient amount, these elements will cause the final failure of a structure. Explanations for the failure of iron and of iron structures, in the past, have been sought for in theories of vibration and shock; had these theories included an investigation of the "elements of disintegration" in the iron, they would have had more satisfactory results.

During the days of iron structures, but little attention was given to its impurities by manufacturers and practically none by engineers, so that we may say that iron has passed without our really having known it.

Phosphorus and sulphur are the most common, the most dangerous, and the most readily controlled of the "elements of disintegration," and it is these two elements on which the A. A. S. M. specification has placed limits. For boiler and fire-box steel this specification limits both phosphorus and sulphur; for structural steel the phosphorus only is limited.

The question naturally occurs, if a sulphur limit is good for boiler plate, is it not also good for bridge steel?

A much used but now threadbare argument has been advanced, that if the engineer took care of the phosphorus the manufacturer could be trusted to take care of the sulphur. This argument was doubtless made in good faith at first, but increased knowledge has shown that the neglect of sulphur sometimes leads to disastrous consequences.

No manufacturer will let the sulphur run so high in his steel that it will break up when he is rolling it, but between this point and safety there is a zone of sulphur in which steel will apparently roll and finish all right, without visible defects, but be filled with invisible cracks which Mr. Thos. Andrews, F. R. S., M. Inst. C. E., calls micro-sulphur flaws.

As sulphur is a hot-shortener it is but natural to assume that when steel is cold, sulphur is no longer to be feared; well and good, if it has not done its treacherous work beforehand. Many failures of steel which have been credited to phosphorus, a thorough investigation would doubtless have shown to be due to "micro-sulphur flaws" alone, or as an able assistant to phosphorus.

Let us thank the American Association of Steel Manufacturers for having given us phosphorus and sulphur limits; not so much for the limits themselves, as for the official recognition that limits are good.

To be sure we must still take, under this specification, for railway bridges, acid open hearth, basic open hearth, acid bessemer, or basic bessemer, straight or mixed, as it may come to us, but in this respect the specifications is no worse than many individual specifications, and in the fact of having chemical limits, it is far in advance of them.

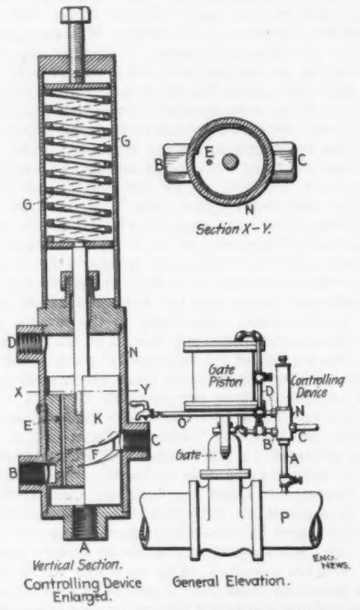
A. C. Cunningham, M. Am. Soc. C. E.

Albany, N. Y., Aug. 14, 1896.

(We reprint the revised standard specifications of the Association of American Steel Manufacturers on another page.—Ed.)

### A Device for Operating a Gate from a Distance by Hydraulic Power.

Sir: In designing the new gravity system of waterworks recently completed at Astoria, Ore., it was desirable to use a small reservoir, already constructed, for the supply of the low service distribution, although the elevation of this reservoir was insufficient for a first-class fire protection directly from the hydrants, and to construct the new reservoir at such an elevation as to properly supply a higher service, while when connected direct with the low service a suitable fire preasure would be secured. This plan presented the advantages of a moderate pressure for ordinary domestic consumption, and an increased fire pressure when required. The necessity at once arose for a means of readily operating the gates between the high and low services in case of fire; and it was desirable that these gates, two in number, should be both opened and closed from the central fire station. To meet this requirement the writer, in preparing the plans for the works, devised a governor for a piston lift gate, a print of which is enclosed, and which it is believed, will be of interest to many of your readers, inasmuch as this question of operating gates from a distance is one which has attracted some attention, and is often desirable of accomplishment, especially in connection with the use of stand-pipes and direct pressure for fire protection, and to accomplish the speedy closing of large supply mains in case of disastrous breaks.




A Device for Operating a Gate From a Distance by Hydraulic Pressure.

The manner of operation and general arrangement of the parts is as follows: In the cylinder, N, is a close-fitting piston, K, which moves in opposition to the spring, G. The cylinder, N, has provision for four pipe connections, A, B, C and D. Connections B and C freely communicate together by way of the inclined port, F, cut around the piston, when the piston is at the lower end of the cylinder. When the piston is raised the opening, C, is closed, and the opening, B, has free communication with the opening A. The opening D is always unobstructed whatever the position of the piston. A small hole is drilled through the piston longitudinally as shown at E, which gives free communication between the two ends of the cylinder. This hole is drilled of such size as to have a less delivering capacity under the pressure at which the gate operates, than the small pipe extending from the governor to the point from which the gate is to be operated. In operating, A is connected with the pressure pipe in which the gate is placed, a screen being inserted between the main and the governor to prevent the passage of sediment; B is connected with the lower end of the gate cylinder; C with the waste; D with the upper end of the gate cylinder with a tee connection, in one branch of which is connected the line of small service pipe leading to the station from which the gate is to be operated. At the end of this pipe is placed a stop cock or other convenient means of opening and closing the pipe. Under normal conditions this cock is closed, the water has free access from the pipe P through A, E and D to the upper end of the gate cylinder, thus acting on the gate piston and keeping the gate closed. There being an equilibrium of pressure in the two ends of the governor cylinder, the piston remains at the lower end of the cylinder. When it is desirable to open the gate, the pipe at the controlling station is opened, releasing the pressure in D, causing the piston to be thrown to the upper end of the cylinder, which act closes C, and opens B to the passage of the fluid from A, which, acting on the lower end of the gate piston, causes the gate to open while the water from the other end of the gate cylinder passes off through the pipe, O, at the controlling station. By closing the pipe at the controlling station, equilibrium is again gradually restored in the two ends of the governor cylinder through the opening, E, when the spring, G, throws the piston to the lower end of the cylinder, releasing the water from the lower end of the gate cylinder through the openings and movable port B, C and F, while the pressure being again applied to the upper end of the gate piston, causes the gate to close. By reversing the connections between the governor and the gate cylinder, the gate can always be kept open instead of closed while the pipe at the controlling station is kept closed.

This governor has operated perfectly from the very first, and responds instantly to the opening and closing of the cock at the governing station, and the gate operates without production of appreciable ram in the pipes. A check valve placed in the supply pipe from the lower reservoir closes with the back pressure, cutting out the reservoir while the fire pressure is on.

Yours truly, A. L. Adams, M. Am. Soc. C. E.

Astoria, Ore., April 18, 1896.

### The "Student" Grade of Membership in Engineering Societies.

Sir: Some time since I saw in an article in a technical journal a reference to "Students of the Institution of Civil Engineers." Would you kindly inform me and several other young engineers, whether these Students constitute men yet in college or young graduates out in life, and in what manner these Students pursue studies under the Institution. Please also let us know if the American Society of Civil Engineers has a Student grade, and if so, how admittance can be had to it. Very sincerely,

E. L. T.

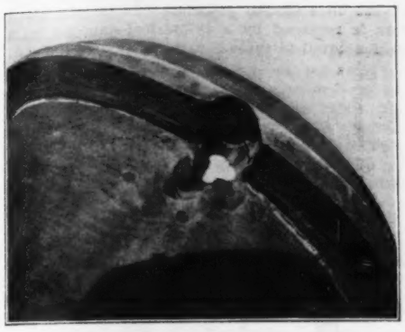
Baton Rouge, La., Aug. 18, 1896.

[The Student of the Institution of Civil Engineers pursues no regular course of study under the Institution. He is simply entitled to attend the "Ordinary Meetings," to use the library, and to receive a copy of the published papers of the Institution; but he has no vote. He must be over 18 years of age, and be, or have been, a pupil under a Corporate Member of the Institution, under the English system of apprenticeship, or as an articled student of engineering under a practicing engineer. He must be recommended to the Council by the Corporate Member with whom he has served, and unless transferred to a higher grade he loses his connection with the Institution on reaching the age of 25 years. The annual dues are about $10 for a Resident and $5 for a Non-Resident Student. The American Society of Civil Engineers has a practically similar grade of member in its Juniors. This Junior must not be less than 18 years of age and have had at least two years active experience in the practice of some branch of engineering, or have graduated from an engineering school of recognized standing. He loses his connection with the Society upon reaching the age of 30 years, unless meanwhile transferred to a higher grade. His privileges are prac-

tically the same as those noted for the Student of the Institution, and both can have acceptable papers published in the proceedings of the societies. The entrance fee of a Junior is $10, with $10 annual dues for a Non-Resident and $15 for a Resident Junior. The purpose in establishing the grades of Student and Junior is to enlist the young men in the aims of these societies, to enable them to profit by the experiences of the elder members of the profession and to give them an opportunity of placing upon record any useful experiences they may have themselves. It is a valuable connection in both cases for the young engineer. By addressing the Secretary of the American Society of Civil Engineers at 127 East Twenty-third St., New York city, any applicant can obtain the constitution and full information on this head.—Ed.]

### A Peculiar Break in a Water Main.

Sir: We mail you to-day a photograph showing a peculiar break in a 36-in pipe line. The point on the line where the break occurred is a sandy bottom along the edge of Stony Creek, and the leak was noticed for two months before we had an opportunity to work at it. Upon uncovering we discovered the state of affairs as shown by the photograph, which is unsatisfactory so far as showing



Sand-Jet Effect Upon a Cast-Iron Waterpipe.

the depth of the cutting of the metal is concerned. The pipe was laid in sand free from acids, so that the cutting was not due to chemical action. An attempt was made to cover the orifice with a patch, as will be noticed by the drilled holes, but was not successful, and pieces of two pipes were removed to make a complete repair. When first uncovered the surface of the orifice was brightly polished, and the edges were sharp, showing that the enlargement, at least, of the hole was caused by erosion. The water carried by this line is reasonably free from sand or mineral sediment. Yours truly,

A. H. Walters, Secy.

Johnstown Water Company,
Johnstown, Pa., Aug. 20, 1896.

(This is doubtless a case of sand-blast action, the sandy soil furnishing the cutting material and a jet of water escaping from a leak in the joint supplying the power. In the "Transactions of the American Society of Civil Engineers," Vol. VII., page 14, will be found illustrated and described an almost similar case happening in the Philadelphia Water Department in 1878. In the Philadelphia case referred to the water-pressure was about 90 lbs. to the square inch, and a cast-iron pipe ⅝-in. thick was cut through in four days. Mr. Walters does not mention the pressure on the Johnstown pipe, but as the "blast" was in operation for at least two months the result is not remarkable. Judging from the photograph only and the vertical as well as lateral evidences of scour, there may have been several jets at work at the same time.—Ed.)

## THE SEWERS AND SEWAGE FARMS OF BERLIN.

In August, 1894, the Prefect of the Seine sent a French government engineer, Mr. F. Launay, to Berlin to investigate the system of sewerage and sewage disposal of the German capital. The report of this engineer, published in the "Annales des Ponts et Chausees," of September, 1895, praises these works highly. The city has a population of about 1,600,000, including the suburbs, and an area of 15,586 acres; in 1874 it was without a sewerage system, while in 1894 the total length of sewers was 462 miles, and over 22,000 acres of land was embraced in the tracts used for purifying the sewage of the city. The construction of the works has been followed by a fall in the death rate from 32 to 20.2 per 1,000. "The most surprising feature in this great work," according to Mr. Launay, "is the rapidity with which it was planned; the methods, once studied out and adopted, have been followed without long or futile discussion with that force of will, that calm perseverance, that strong stubbornness, and, in a word, that spirit of discipline which is marked in the German character.

When the government became convinced that sewerage works were imperatively needed, it sent a commission to France and England to study the methods of sanitation practiced in those countries. Professor Virchow and Director Hobrecht, of the department of municipal works of Berlin, took an active part in this work and the latter was selected to prepare the plans and build the works. His report concluded with a statement to the effect that it was inadmissible to allow sewage to enter the Spree River, which passes through the city, but it should be pumped to irrigating fields in the suburbs; chemical treatment was said to be too costly as well as insufficient.

The city was divided into twelve independent districts, corresponding with slight differences in topography. Each of these basins was called a radial system and was provided in the plans with a system of sewers receiving both storm water and house sewage, and a pumping station for forcing the sewage to the irrigating fields. The part of the city south of the Spree as far as the Landwehr Canal comprises three systems: System I. is at the east, while at the west Systems II. and III. are separated by a line running from the Anhalt railway station to the Spittel market. North of the Spree are Systems IV. and V. To the south of the Landwehr Canal and separated by the Anhalt, Potsdam and Dresden railway stations, are Systems VI. and VII., at the east and west respectively; these also take in parts of Charlottenberg and Schoneberg, which are connected with the Berlin sewerage system by reason of a special agreement between the authorities of the cities. System VIII. comprises the Moabit district at the west of the city, and System IX. extends to the northwest. Finally, Systems X., XI. and XII. extend from the north to the east around the outskirts of the city. The island of Cologne is connected with System III. and the island of Berlin with System IV. The district adjoining the Zoological Gardens is connected with System VIII. by a syphon 282 ft. long, across the Spree. Systems I. to VIII., inclusive, and XII. are now in use; System XI., where the district is not yet built up, has not been begun, and the remaining two are incomplete.

The city is situated on a great sandy plain, with barely perceptible differences in elevation, and on this account the location of the pumping stations was a delicate problem. Wherever possible an attempt was made to select the lowest point in the system in order to give the sewers a grade corresponding with the natural slope of the surface. It was also necessary to keep near the public water ways in order to make as efficient as possible the interceptors which will be explained later. In the outskirts of the city, where the length of the force mains to the fields was reduced, it was possible to adopt less powerful pumps and to reduce in a corresponding measure the expenses of construction and operation. In some cases, the solution of a site for the stations was determined solely by the possession of suitable property for the purpose by the city.

When the location of the pumping station had been settled a system of channels was devised. In fixing upon the maximum of run-off per second from any surface the following assumptions were made: Maximum for household waste, 0.054 cu. ft.; for rainfall, 0.3; or, together, 0.354 cu. ft. per sec. per acre. The sections of the sewers were determined, according to the Eytelwein formula for full pipes. The pumps are all horizontal; and some of the engines are compound, controlling two pumps, and others are single, with one pump. But all the pumps in any one plant are alike in every part. The boilers are all tubular, and the buildings themselves are handsomely furnished and contain lodgings for the inspector and chief mechanic, dining-room, baths and places for drying the clothes of the workmen. The pumps are all of the piston type; excepting for a relay plant in System III., where a centrifugal pump is installed. The pumps in System IX., recently established, are compound machines, making 50 strokes per minute, on the Reidler system.

Each radial system is subdivided into basins, each of which has a collector leading to the lifting plant. The collectors, consequently, have the greatest length and the least fall and receive throughout their course either the direct drainage or the sewage from secondary collectors. The primary branches have the heaviest gradients and the least section. The depth of the water-line, at the head of any collector-system, varies from 4.8 to 8.2 ft. beneath the surface soil; at the pump-well the level is determined by the fall required in the system. At the lifting plant all the collectors unite in a common trunk, which empties into a sand-basin. This basin is essentially a sump, 39.36 ft. in diameter, divided on its diameter, into two equal parts, by a vertical grating of iron bars which leave an open mesh about 0.6-in. square. The velocity of flow in the sewage is checked by the sudden enlargement of the section of channel and by the sand, and the grating catches matter in suspension, which might otherwise clog the pumps. The foot-valve of the pump is placed in the sand-basin on the other side of the grating; or where the arrangement of the pump does not permit this a special channel leads from the sump to the suction pipe.

The sewers themselves, for three-quarters of their aggregate length, are made of vitrified clay pipes ranging from 8¼ to 19 ins. in diameter. The masonry sewers have an ovoid section varying from 2.95 to 6.56 ft. in vertical height. The following table of totals is taken from a full table showing each radial system in detail:

| | |
|---|---|
| Masonry sewers, length | 471,801 ft. |
| Pipe sewers, length | 1,909,429 " |
| Waste-weirs, masonry | 50,623 " |
| Waste-weirs, pipe | 13,307 " |
| Manholes | 2,005 |
| Inspection shafts | 8,874 |
| Sewer inlets | 14,204 |

The sewer-inlets or catch-basins, are built of brick masonry and are located about 200 ft. apart on each side of the street, near the curb. They are covered with gratings and admit to the drainage system all the rain falling upon the streets. These basins are cleaned out at regular and short intervals, and the connection between the basin and the sewer is made by a short section of pipe closed by a grating which arrests all floating matter.

For the purpose of visiting and ventilating the system inspection shafts are placed every 200 or 260 ft. apart, or wherever the pipe sewers change in diameter or in horizontal or vertical direction. These openings are 3.1 ft. in interior diameter, and are so numerous that the whole system can be inspected, flushed and cleaned. The top of these openings is closed at the street surface by a perforated plate; the purpose being to assure air communication between the sewers and the streets. When it is considered that the total capacity of the Berlin drainage system is only 5,300,000 cu. ft. the importance of this arrangement can be better appreciated. During heavy rainfalls the sewers are completely filled and the air is forced out of the perforated plate with violence; but, on the other hand, the accumulation of compressed air at the higher points is prevented, and consequently the drainage back of the water and flooding of certain districts is avoided. The ventilation of the sewage system is also an important end gained.

The waste-weirs referred to connect the sewers with the nearest natural waterway and are used to relieve the sewers in the case of heavy rains. The bottom of these discharge pipes is established on a level with the tops of the pipe sewers, and at the springing line of the ovoid masonry sewers. To prevent a flow from the streams to the sewers this discharge channel is controlled by valves. But as heavy rains are rare in Berlin this relief system is seldom used.

One of the faults of the Berlin system is its small capacity, arranged only to perform mean duty. The Paris sewers, with their very large section, not only can care for all the water coming

to them, but also provide a place for water pipes, telegraph and telephone cables and other underground furniture. In Berlin, considerations of economy of first establishment and a reduction in the cost of maintenance prevailed. When the waste-weirs commence to act in that city it is figured that the proportion of household waste to rainfall is 1 to 16; and with a water consumption of 60 litres (16 gallons) per head per day, the proportion of excremental matter is 1 to 100. This corresponds to a dilutation of 1 in 1,600; a rate which descends to 1 in 15,000 when the waste conduits are in full operation.

The pumping mains, leading to the sewage farms, have their upper side buried about 3.3 ft. below the normal street level, and they generally follow the undulations of the surface, having air-valves at all high points, which are opened daily. The diameter of the cast-iron pipe used varies from 2¼ to 3½ ft., and riveted iron pipe is employed in crossing streams and railways.

The house connections in Berlin are worthy of note. Building is regulated by a police ordinance of July 14, 1874, and by a municipal ordinance of Sept. 4, 1874. The police ordinance requires every owner of a house to make a connection with the sewers, either by a waste pipe or by a special connection to be used for the water-closets alone. All the old privy vaults have disappeared, and it is forbidden to build new ones. The house owner has six weeks from the date of notice to present to the city authorities for approval a complete plan of the contemplated sanitary appliances to be put in his house; and six weeks after the approval of these plans the installation must be completed.

This installation is controlled by the following rules: Every drain-pipe must be trapped and connected with a pipe carried above the roof or ventilated by communicating with a chimney; every sink must be provided with a grating; water-closets must have a water-seal and the pipe is limited to a diameter of 2¾ ins.; upon the direct house connections and directly back of the front wall of the house and between this wall and an automatic valve must be located a water-trap, which can be inspected. Rain-water pipes from the roof must be provided with a grating and a water-trap, so as to retain solid matter coming from the roofing. And, finally, special authority is necessary to carry to the sewers any industrial waste or exhaust steam.

The municipal decree orders that the connections under the pavement are to be built by the city at the cost of the proprietors; only the interior work can be put in by the latter. The introduction of water and the sewer connection are obligatory, and each house bordering on a sewerage system pays a quarterly tax, according to its rental value, which is devoted to meeting the interest on the cost of construction and maintenance of the sewers. The amount of this tax is fixed annually by the administration, and in 1894 was 1% on the net revenue from the house.

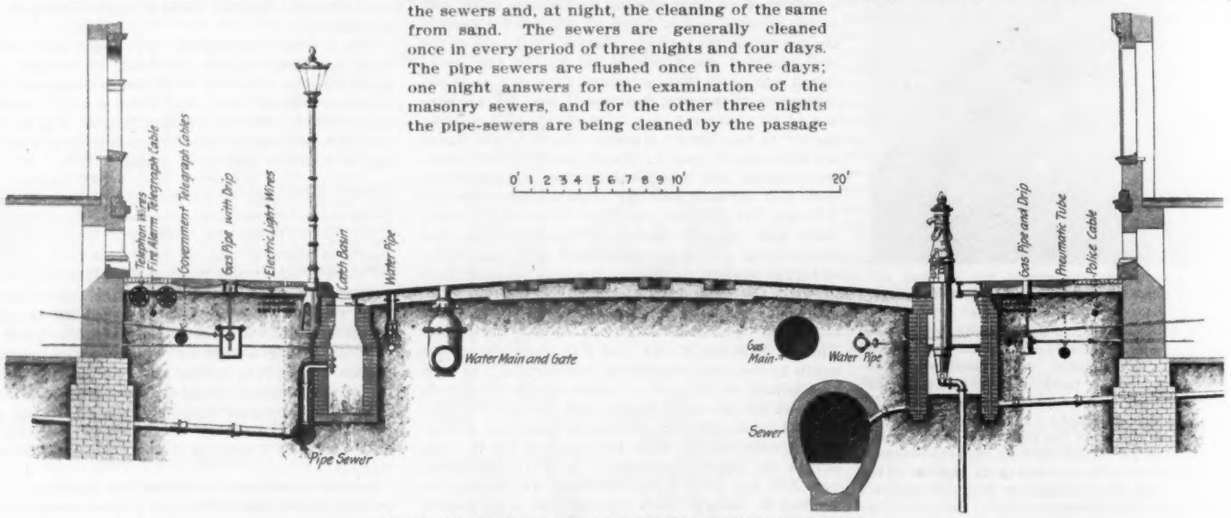
The actual surface of the city drained by the present eleven radial systems is about 13,210 acres; the streets included represent a length of 314 miles, covering a superficial area of 3,366 acres. The total length of all the sewers, on April 1, 1894, was 450 miles, not including the relief sewers. The number of manholes and inspection shafts together was 10,879, and there were 14,204 catch-basins.

The entire service of maintenance, up to the limits of the sewage farms, is under an inspector having under him a number of special inspectors, the latter usually caring for two systems. The inspector has under his charge at each lifting-plant a chief-mechanic, 3 to 7 enginemen, 2 to 4 firemen, coal-handlers, etc. For the maintenance of the sewers of any system he has from 2 to 4 foremen with 6 or 12 workmen. Each foreman directs three laborers or more, according to the district assigned him. A district includes from 1,000 to 1,200 houses, and from 35,500 to 85,000 inhabitants; it also includes 15½ to 23½ miles of sewers, with 350 to 550 manholes, 450 to 680 catch-basins and from 1,500 to 2,000 house connections. The foreman is responsible for the care of tools, the inspection and cleaning of the sewers, and notes daily the amount of water used in cleaning the sewers and the quantity of sand taken from them. He examines all the house connections and ascertains that they are working properly; he supervises the regular flushing of the sewers and, at night, the cleaning of the same from sand. The sewers are generally cleaned once in every period of three nights and four days. The pipe sewers are flushed once in three days; one night answers for the examination of the masonry sewers, and for the other three nights the pipe-sewers are being cleaned by the passage of a special broom through them. In cleaning the larger sewers, two workmen, provided with boots, are employed; one of these pushes before him with a scraper all the mud, rags, paper, etc., and the second workman follows with a broom and cleans up the invert. These men usually enter at the head of a sewer at 7 a. m., and by 5 p. m. arrive at the sump of the pumping plant. During this time a third workman follows along the street and opens the manhole plates in advance of the two below, thus giving them pure air. It is also usual to have a man at the grating in the central sump to prevent it from being stopped by rags and paper.

The flushing is commenced at the highest point in any sub-system. The flushing tank is filled from the water mains, after the opening leading to the sewer has been closed by a stopper connected with the street by a chain. The tank is emptied at once by pulling out this stopper, and the flushing stream flows on down the system.

The broom-cleaning of the pipe-sewers referred to is done in the following manner: A float with an oiled cord attached to it is passed down one of the manholes into the pipe; to this cord is fastened a tarred cable fixed to a cylindrical broom of "piazzava" fiber which has another cable fixed to the other end, so that if one cable breaks the broom can be hauled out by the other. Two workmen and one foreman draw the broom forward by the aid of a reel; another takes away with a shovel the sand coming to a manhole, and a fourth man manages the rear cable and regulates the flow of distribution water for the cleaning of the sewer. Usually, three brushes of different diameters are used, one after the other, the last having the same diameter as the pipe. The sand is usually removed from the large sewers at night. For this service from 5 to 7 men are required, and the deposit is only removed when it acquires a depth of about 6 ins. One workman shovels the sand into buckets, which are carried by four men, two to each bucket, to the nearest manhole, where two other men lift them to the street.

This somewhat antiquated method of cleaning has of late years given way to an automatic flushing device. This is essentially a dam made of planks and cut to conform nearly to the section of the sewer. This dam is made in sections, united by bolts, for convenience in passing it into the sewer, and is provided with rollers above and below, and is kept in an upright position by a rear brace and guide rollers. It acts as a dam and permits the water to escape under a head through the opening at the bottom, cutting away and driving before it the sand in the sewer. This device is especially servicable in the sewers under 2½ ft. in height into which it would be difficult for workmen to enter. A new device, here illustrated, is also being used in clearing the pipe sewers on a similar principle. In this the plank dam is replaced by a cylindrical dam having a section equal to three-fourths of that of the pipe. To keep the open section down and to guide it, three heavy balls are made to roll in the bottom part.




STANDARD CROSS SECTION OF STREET; BERLIN, GERMANY.

The description of the sewage farms comes next. As showing the growth of the system of sewage irrigation, it is sufficient to say that in System I. the mean daily delivery was 150,000 cu. ft. in the year 1880-81; in 1893-94, the same system delivered 500,000 cu. ft. daily. In the same period the flow from System IV. increased from 230,000 to 1,253,856 cu. ft. per day. It is interesting to compare the quantity of water actually distributed in the city by the municipal service and the quantity sent by the pumps to the sewage farms. In the year 1893-94 the pumps delivered 2,240,000,000 cu. ft., or 16,800,000,000 gallons of sewage water; about 28 gallons per day per inhabitant. During the same period the average of water distributed from the city mains was 18 gallons per head per day. The extra 10 gallons came from the rainfall and water from industrial establishments originally obtained from wells or from natural streams; and included in this was the solids from the houses.

The natural conditions of the soil acquired by the city of Berlin for its sewage farms are far from presenting the most favorable qualities for purification purposes. The sandy dunes are less permeable than the gravels of the Valley of the Seine, and they rest upon an impervious bed, located at a light depth below them. In fact, the filtering bed is less than 3.3 ft. deep at some places and at no

point exceeds 5 ft. The land acquired is in two groups; the first is to the northeast of Berlin and about 1.8 miles from the edge of the city; the second lies to the south and is about 7.2 miles distant. Of the whole 22,230 acres included in these fields, about 78% is represented by irrigation fields. The remainder is taken up by courts, gardens, parks, woods, roads and buildings. Of the total surface, about 70.3% is drained; or 96% of the irrigation area proper. This preliminary drainage is an absolute necessity, owing to the light depth of the filtering bed.

The distribution of sewage over these fields is controlled by a system of cast-iron mains with gates, and secondary conduits, some in pottery and most of them in the form of open drains, buried at least 1.6 ft. and having suitable fall. The principal conduit, leading from the pumping station, abuts at some point on the farm and terminates in a stand-pipe of the same diameter as the pipe. The branches of the distribution pipes terminate at high points and are closed with valves, the diameter of the pipe descending to 10 ins. There are about five of these valves to every 247 acres of irrigated land, and the pipes end in "swan-necks," with the escaping water falling into a circular basin or into trenches. At some places the pipes empty into a rectangular basin, 13×40 ft., 6½ ft. deep. These basins deposit the sand and the water in them is made to pass through facines which catch all matter held in suspension.

The beds for "running culture," or for cereals, carrots, potatoes, beans, fruit trees, etc., are arranged as at Gennevilliers (Paris sewage farm; see Engineering News, Aug. 25, 1895), in ridges and furrows. The furrows are from 65 to 98 ft. long; have a width of from 12 to 18 ins. and their depth is from 18 to 40 ins. The ridges thus formed are from 3 to 5 ft., c. to c.; they are generally united in great beds, 20 to 30 ft. on a side and in series of six, with a small dike around them. The prairie or grass beds are usually 200 ft. long by 130 to 160 ft. wide, and they are watered for three or four hours every three days. Certain other basins are set apart for winter use, or for filtration only, no kinds of cultivation being attempted. These basins receive the water in successive beds from 12 to 18 ins. deep, kept in place by dikes.

The experience with the Berlin sewage farms, as at Gennevilliers, proves that there is no burning out of the soil, no swamp-formations, and no necessity for reducing the doses of sewage water at the end of a certain time.

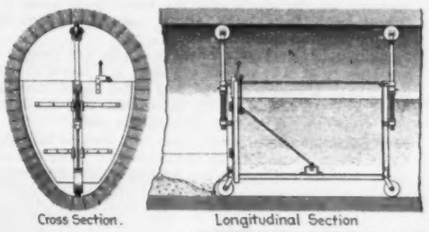
Periodical and methodical analysis will show the constancy of the effluent, or purified sewage, as being clear, pure, inodorous and free from microorganisms. No epidemic has justified the sinister predictions of the adversaries of sewage farming. The health of the people living on these irrigated fields, carefully controlled by the administration, is always excellent, and the city of Berlin has not hesitated to establish homes for convalescents upon these fields; one at Blankenburg, for 40 women; another at Heinersdorf, for 40 men; a third at Malchon, and a fourth at Blankenfelds. These asylums are recommended by the physicians and are well filled.

As to cost, the following items are interesting: The mean daily wages paid to the workmen are 48 to 60 cts., with lodging, to the foremen of irrigation; 24 to 43 cts. to the workmen who instead of lodging receive 3,000 kilos. (6,600 lbs., or 110 bu.) of potatoes per year, or the land for cultivating them. The occasional laborers receive 36 to 60 cts.; the women, 19 to 24 cts.; and workmen caring for the fruit trees receive 60 to 72 cts. per day. Work is sometimes given as a task, and in this case the daily wages are increased 20 to 50%. At certain points the field work is done by vagrants taken from the houses of correction in Berlin, sent to the fields under guard and lodged in barracks.

The cost of managing the sewerage system in the city of Berlin, for the year 1893-94, was about $14,000; of which $12,900 was for the personnel and the remainder for sundries. In addition to this sum $820 were spent for gaging and $1,565 were set aside for the hospital for sick or injured workmen. The aggregate cost of operating the several radial systems, for the same year, was about $246,000. The average quantity of water taken from each house, etc., for the year 1893-94 is shown in the following summary of a detailed table for each radial system:

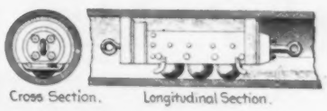
| | |
|---|---|
| Total quantity sewage pumped pr year, gals. | 16,343,000,000 |
| Total houses connected with sewers | 22,611 |
| Sewage water per day per house, gallons | 1,979 |
| Total number of inhabitants | 1,591,791 |
| Sewage pumped per day per head, gallons | 280 |
| Cost of operating, per head, cts. | 14 |
| Cost of pumping per 1,000 gallons, cts. | 0.934 |
| Total of sewer maintenance and pumping, 1,000 gallons, cts. | 1.352 |

The total quantity of sand and refuse matter of all kinds taken from the drainage system in one




DEVICE FOR CLEANING SEWERS AUTOMATICALLY.

Oval Sewers.




Pipe Sewers.

year amounts to 130,000 cu. ft. taken from the sumps at the pumping station, and 299,000 cu. ft. taken from the masonry and pipe sewers; a total of 429,000 cu. ft. In relation to the total quantity of sewage water pumped and other solid matter taken from the sewers and the sumps at the pumping-station the dilutation is as about 1 to 5,000. The amount of solid matter still left in the sewage after passing the pumping-station is given in the table of analysis below, as 65 parts per 100,000.

The improved drainage of Berlin has had an undoubted beneficial effect upon the health of the citizens; and while other factors have assisted in bringing about this better condition, the drainage system seemingly stands first in potency, as is shown by the following table:

| Year. | No. houses connected with sewers. | Mortality per 1,000. | Year. | No. houses connected with sewers. | Mortality per 1,000. |
|---|---|---|---|---|---|
| 1873 | ..... | 30.0 | 1883 | 11,908 | 28.9 |
| 1874 | ..... | 30.2 | 1884 | 14,100 | 26.5 |
| 1875 | 57 | 32.9 | 1885 | 15,895 | 24.4 |
| 1876 | 1,025 | 29.8 | 1886 | 17,395 | 25.6 |
| 1877 | 2,014 | 29.7 | 1887 | 17,955 | 21.8 |
| 1878 | 2,415 | 29.5 | 1888 | 18,479 | 20.3 |
| 1879 | 3,602 | 27.5 | 1889 | 18,984 | 23.0 |
| 1880 | 7,478 | 29.7 | 1890 | 19,898 | 21.5 |
| 1881 | 9,867 | 27.2 | 1891 | 21,352 | 20.9 |
| 1882 | 10,468 | 25.9 | 1892 | 22,012 | 20.2 |

Each year the city prepares new land with a view to irrigation; by leveling the surface, tracing out and digging the ditches and irrigation trenches, by building dikes, limiting the beds or basins, and by building roads, etc. Over almost the whole irrigated area the initial drainage of the subsoil is considered very important and absolutely necessary, so as to obtain a filter of sufficient depth. The drains are made of terra cotta pipe, 2⅜ to 2¾ ins. in diameter and ⅝-in. thick, placed end to end and united by sleeves of terra cotta. The water enters at the joints and the lines of drain-pipe are laid about 26¼ ft. apart and they are sunk 5.8 ft. below the surface of the soil; and all abut upon a main drain, about 4 ins. in diameter, leading to an open ditch. Of the total 22,230 acres owned by the city a little more than one-half is now regularly farmed. Some of this land is rented out by the city at a rental of about $20 to $23 per acre, when irrigated; and at $8 per acre when not irrigated or prepared. The total amount of sewage water delivered, in 1893-94, upon 11,542 acres was 16,791,017,000 gallons. This corresponds to 1,455,000 gallons per acre per year, and to about 4,000 gallons per acre per day. The total monthly flow oscillates between a maximum of 1,578,859,000 gallons in July and a minimum of 1,192,070,000 gallons in April.

The table below gives the chemical composition of the sewage taken as it comes upon the farm from the pumps, and three specimens of the effluent taken from the vegetable and fruit farms, the grass lands, and finally from the winter outflow:

(Parts per 100,000.)

| | | Effluent, from— | | |
|---|---|---|---|---|
| | Sewage. | Vegetable farms. | Grass land. | Winter o'fl'w. |
| Dry residue | 65.00 | 70.00 | 80.00 | 115.00 |
| Loss on ignition | 18.00 | 10.00 | 10.00 | 22.00 |
| Residium; ignition test | 47.00 | 60.00 | 70.00 | 93.00 |
| Ammonia | 6.50 | .10 | .30 | 1.70 |
| Nitrites | ..... | .14 | 1.00 | 1.35 |
| Nitrates | ..... | 14.00 | 12.00 | 1.60 |
| Phosphoric acid | 2.00 | ..... | .10 | .14 |
| Sulphuric acid | 2.00 | 4.00 | ..... | ..... |
| Chlorine | 13.00 | 15.00 | 17.00 | 32.00 |
| Potash | 4.00 | 2.00 | ..... | ..... |
| Soda | 12.00 | 16.00 | ..... | ..... |
| Bacteria, per cu. cm. | 100,000,000 | 23,000 | 50,000 | 60,000 |

The total expense of the joint construction of the drainage system of Berlin, up to March 31, 1894, was about $22,000,000. Of this about $14,900,000 went for the drainage system and $7,100,000 for the sewage farm, about $4,000,000 of the latter being for the cost of land.

The radial Systems I. to X. and XII., excepting the suburbs of Charlottenburg and Schoneberg, include 22,151 houses, of which 22,091 are drained and united to the drainage system. The corresponding population is 1,563,938 and the amount of sewage removed annually is 16,791,017,000 gallons. From these elements we may arrive at the following conclusions: The cost per inhabitant has been $13.54, of which $9.15 were for the drainage system, and $4.39 for the irrigation fields.

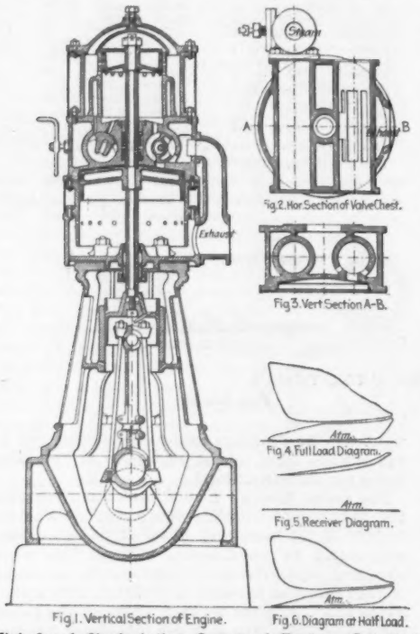
The annual cost of administration and maintenance, the clearing and care of the sewers, pumps and machinery, is $337,000; the maintenance of the sewage farms costs annually $510,000; interest upon capital amounts to $1,046,000, a total annual cost of $1,893,000. The revenue from 22,091 houses amounts to $732,000, and the revenue from the products of the sewage farms is $446,000; a total of $1,178,000. The difference of $715,000 between expenses and revenue is covered from general receipts of the municipality.

The author concludes by comparing Berlin with Paris, as follows: Berlin has not quite 23,000 houses to 1,563,938 inhabitants; while Paris has 82,500 houses to 2,500,000 inhabitants; amounting to an average of 70 persons per house in Berlin and 30 per house in Paris. In Paris, the daily outflow of sewage water is 105,700,000 gallons, of which the excremental matter would amount to 832,000 gallons, or 0.78%. In Berlin, the daily volume of sewage is 45,440,000 gallons, of which the solids represent 520,000 gallons, or 1.14%. While the filtering soil on the Berlin sewage farms is thin, less permeable and only permits an average dosage of 4,000 gallons per acre per day for the whole year, the deep sandy soil of the Valley of the Seine will admit of a dosage of some 11,400 gallons per acre per day.

## A NEW SINGLE-ACTING COMPOUND HIGH-SPEED ENGINE.

We reproduce from "Engineering" an illustration of a new vertical single-acting compound high-speed steam-engine, built by the Brush Electrical Engineering Co. (Limited), of London, under patents of their chief engineer, Mr. J. S. Raworth. It is designed especially for direct coupling to a dynamo. Referring to Fig. 1 it will be seen that the high and low pressure cylinders are mounted tandem, the former, which is on top, receiving steam on the up-stroke, and the latter on the down-stroke. Steam is admitted to the upper cylinder by a Corliss valve, and another Corliss valve performs the somewhat complex function of transferring the steam exhausted from the high-pressure cylinder partly directly into the low-pressure cylinder and partly indirectly through the receiver, and also exhausts the steam from the low-

pressure cylinder. Fig. 2 is a horizontal section through the center of the valve chests and Fig. 3 a cross section of the chest showing the three parts covered by the low-pressure valve. Figs. 4 and 6 are diagrams taken respectively at full load and at half load, and Fig. 5 is a diagram of the



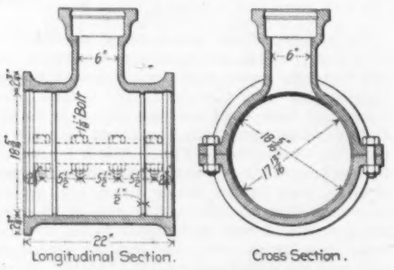

**High-Speed Single-Acting Compound Engine. Patented by J. S. Raworth. Built by the Brush Electrical Engineering Co., London.**

receiver pressure at full load, on double the scale of the steam diagrams.

The bottom of the low-pressure cylinder is always open to the exhaust, while the upper portion of the high-pressure cylinder is in full communication to the receiver, except for a short time when the piston is near the upper end of its travel. Each cylinder has in its wall a ring of holes which acts as a supplementary exhaust. The upper holes, however, pass very little steam, because the pressure in the cylinder when they are opened is practically the same as that in the receiver. The lower ring of holes serves to drain the water out of the low-pressure cylinder. The high-pressure valve is operated by an eccentric under the control of a shaft governor, while the low-pressure valve is worked by an eccentric with a fixed stroke. The mechanical details of the engine contain a number of novelties, the leading idea being to render every part capable of being handled and adjusted by a mechanic of limited skill so that minor repairs may be made without calling in outside assistance.

## A SPLIT SLEEVE FOR MAKING CONNECTIONS WITH WATER MAINS IN PLACE.

The following information regarding a special casting used for making 4, 6 and 8-in. connections




**Split Sleeve For Making Connections With Water Mains in Place.**

with 16-in. or larger mains without cutting the pipe to insert an ordinary tee was furnished us, together with the print from which the illustration is made, by Mr. Wm. R. Hill, M. Am. Soc. C. E., Chief Engineer and Superintendent of the Syracuse Water-Works:

The device is simply a split sleeve with a branch opening. After the main has been partly emptied of water a circular hole of the desired size is cut in the side of the pipe with a chisel. The split sleeve is then bolted on the pipe, and the lead joints are made, completing the connection.

The advantage of this is that the work can be done much quicker and cheaper than to insert a tee. It is unnecessary to entirely empty the main of water, so that there can be no delay if the gates do not entirely shut off the supply as there would be if you were to insert an ordinary tee, in which case the difficulty is often increased by the inability to entirely shut off a section on account of leaky gates.

The trouble of breaking a length of pipe and cutting a new piece to fit in is avoided and there is a saving of two lead joints, a sleeve, and the pipe which would have to be broken. It makes a very substantial connection, in fact a split sleeve tends to strengthen a main.

On the inside of the sleeve there is a bead to hold the hemp, which will insure an opportunity to make a good joint. I would recommend this bead to be on all ordinary sleeves as it will help to make better joints.

On inquiring of Mr. Hill whether he had made use of tapping machines and if so whether he considered this device superior to them, he replied:

We have several connections that were made by a pipe tapping machine. They have caused us a great deal of trouble and we have been obliged to abandon many of them. The split sleeve with the branch was first used at places where the connections made with the tapping machines were defective. We found the split sleeve to work so nicely that we have adopted them for general use.

I do not wish to be quoted as condemning the machine made joint. I think that they could be strengthened and improved. Our trouble with them is perhaps due to the high pressure. We had them under 95 lbs. They might be all right under a moderate pressure. However, any company or department that could not afford a tapping machine would find it an advantage to use the split sleeve with the branch opening.

## WATER CONSUMPTION THROUGH METERED AND UN METERED TAPS AT LEXINGTON, KY.

A striking argument in favor of the meter system is presented by the accompanying table, showing the water consumption through metered and unmetered taps at Lexington, Ky., for the ten years, from 1886 to 1895, inclusive. The use of meters has rapidly increased in the period until now about 90% of the taps are metered. The table was sent to us by Mr. S. A. Charles, Receiver of the Lexington Hydraulic & Manufacturing Co. Mr. Charles comments on the table as follows:

We have had some large consumers both on metered and unmetered taps, who have been quite irregular in their consumption, which accounts for the discrepancies in the average; still, the statement points to a constant increase in waste on unmetered taps and a constant decrease on metered taps, and the final average, showing a proportion of more than 4 to 1, may be safely relied on as being less than the present ratio of consumption between metered and unmetered taps.

**Water Consumption Through Metered and Unmetered Taps at Lexington, Ky., from 1886 to 1895.**

| Year. | Av. No. taps metrd. | Metered consumption, Total. | Av. per meter. | Av. No. not metered | Unmetered consumption Total.[1] | Average per tap. |
|---|---|---|---|---|---|---|
| 1886.. | 33 | 11,738,610 | 355,715 | 238 | 125,706,640 | 528,179 |
| 1887.. | 103 | 25,287,938 | 245,514 | 264 | 134,150,447 | 508,161 |
| 1888.. | 209 | 28,971,068 | 143,402 | 271 | 146,237,405 | 539,621 |
| 1889.. | 344 | 42,648,450 | 123,976 | 267 | 168,479,683 | 631,011 |
| 1890.. | 486 | 75,576,000 | 155,494 | 254 | 209,215,285 | 823,682 |
| 1891.. | 659 | 89,231,348 | 135,404 | 239 | 198,928,352 | 832,336 |
| 1892.. | 829 | 82,642,500 | 99,689 | 230 | 219,229,118 | 953,170 |
| 1893.. | 942 | 84,486,750 | 89,688 | 216 | 255,053,826 | 1,240,990[2] |
| 1894.. | 1025 | 85,349,250 | 83,267 | 217 | 262,645,590 | 1,210,348[2] |
| 1895.. | 1100 | 105,771,750 | 96,161 | 223 | 304,893,045 | 1,367,278[2] |
| | | Av. ten years, 152,531 | | | Av. seven years, 688,023[2] | |

[1]These amounts are determined by deducting from total amount pumped the amount used by city, which can be closely approximated, and the amounts used through meters.

[2]In these years 1893, 1894 and 1895, a large and unknown amount of water was used in settling earth filling in public sewers, and the grand or general average for unmetered taps is therefore based on average of preceding seven years.

## A GERMAN SYSTEM OF METAL STAIR CONSTRUCTION.

The demand for fireproof construction in all details of modern buildings and the necessarily ornamental role which staircases play in buildings of architectural pretensions, has developed the problem of designing stairways into an important study. In Engineering News of April 16, 1895, the general problem of stair design was discussed in considerable detail, and in the accompanying illustrations a type of metal stair construction is shown which can be profitably studied in connection with this general article. The construction illustrated is of Prussian invention, it being marketed and controlled by the Joly Iron Works of Wittenberg, Saxony, which also holds American patents upon the construction. For the matter from which the illustrations have been prepared we are indebted to the firm named.

Fig. 1 explains the general construction of the stairs quite clearly. The stringers a a' consist of parallel wrought iron bars and are braced by similar bars d d' which extend to support the tread. The separators b b' act as stiffening members, and by means of the interior bolts c hold the whole structure together. The risers, which serve merely to cover the open spaces, are made of sheet or cast-iron wrought in ornamental patterns. They are rabbeted into the separators and have projections to which the treads are fastened. The treads consist of iron plates covered with wood or may be entirely of stone, and are ornamented as may be desired. The railing posts may be fastened to the stringers or the vertical bolts may be made long enough to screw up into the posts.

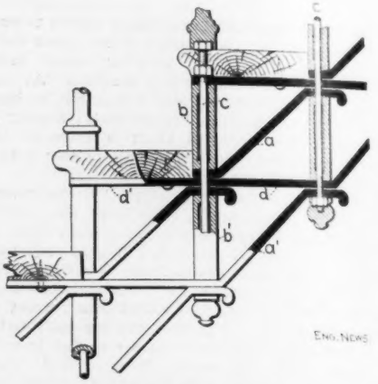



**Fig. 1.--Section Showing Construction of Joly Metal Stair System**

**Joly Iron Works, Wittenberg, Saxony, Manufacturers.**

A modification of this simple design is shown applied to a winding stairway in Fig. 2. This illustration shows the light and handsome appearance of the stringers presented by the structural design alone or with only the simplest ornamental finish. In Fig. 3 the adaptability of the construction to profuse ornamentation is shown.

Besides the designs shown, we have received from the manufacturers, circulars showing a number of other very graceful and pleasing designs, which lack of space prevents us from reproducing, but which could be studied with profit, we are sure, by every architect or engineer interested in metal staircase designing. We presume any of our readers can obtain copies of these circulars by addressing the manufacturers.

Among the claims for these stairs are the constructional advantages of having all the tension members of wrought iron, and the total disuse of splices, bolts and rivets, which detract from a neat appearance. It is also claimed, and quite justly, that the stairs in their simplest form produce a decorative effect. The construction is fireproof, or rather non-combustible, since the risers are solid, and the tread even when of wood has a solid iron plate underneath it. According to a circular published by the manufacturers, the construction has already successfully withstood fire in a burning hotel, and is accepted as a fireproof design by the local officials of Wittenberg.

## IMPERMEABLE COVERING FOR STONE ARCHES.

In the "Revue Generale des Chemins de Fer," for July, 1896, Mr. Leon Malo treats of asphalt as a protection to stone arches against the infiltration of rain-water. From a general point of view the material used for such protection, says Mr. Malo, should be permanent in character, absolutely impenetrable to moisture and it should be slightly elastic so as to conform without rupture to the inevitable movement of masonry in its normal settlement under construction. This covering should also be able to support, without cracking, considerable weights which must be placed upon it.

In his opinion, asphalt alone, of all available materials, possesses the properties required, and it has been so used for a considerable time. Mr. Malo, however, warns engineers that asphalt must be employed intelligently for this purpose, and he proceeds to describe the difference between mere bitumen and mastic asphalt; and it is the latter he recommends for the use here referred to. The peculiar properties of this mastic asphalt are: That its tenacity is considerable; once cooled it adheres with great firmness to a properly prepared surface, and properly spread in a thin bed it will completely preserve the surface beneath from moisture. When mixed with a certain proportion of gravel, according to the use intended, it becomes very hard and presents an extraordinary resistance to wear.

The surface to be protected should first be covered with a bed of cement, smoothed with a trowel. The maximum inclination of this surface should not exceed 45°. When this cement is dry, pure mastic asphalt, that is without sand, is poured upon this cement in a bed from 10 to 20 mm. (2-5 to 4-5 in.) thick, acording to the importance of the work. This asphalt is spread over the cement at a temperature of 150° to 160° C. If the adjacent surface is still wet the water will at once be converted into vapor, and this vapor will escape in bubbles leaving voids below the asphalt terminating in an extremely fine vent. If it is impossible to wait until the cement bed is perfectly dry before applying the asphalt these bubbles can be smoothed down and the vents closed by applying a hot iron. When the asphalt is cool and hardened care should be taken, in filling over it, to first employ only small material, as large stones thrown upon it will crack the thin crust.

Surfaces inclined at a greater angle than 45°, or even vertical surfaces, can be protected in like manner by using greater care. In covering these steep surfaces the cement coating is purposely left rough and this surface should be perfectly dry before the asphalt is applied. Bitumen is then heated in a kettle to 180° to 200° C., and spread with a brush over the sides to be protected, but with as thin a coating as is possible. Upon this the mastic asphalt is spread with a trowel, or a batten of wood, as in the case of ordinary mortar; but care must be taken that the asphalt is kept in place and smoothed down until it is sufficiently cooled to prevent running. This is delicate work, but when executed with competent workmen and materials of the proper qualities it presents no serious difficulties.

Mr. Malo says that 35 years ago he built a dwelling house upon the side of a hill of calcareous rock, deeply fissured and filled with water at every heavy rain. The foundation wall entered into this soil for 20 ins. and the outside of this wall and the entire area covered by the house was spread with a 1-in. coating of mastic asphalt and sand. The house has always been dry from bottom to top, though the foundations, during heavy rains, are surrounded by a sheet of water from the rain.

The practical employment of asphalt as a covering for the arches of railway bridges dates from about 1858, when Mr. Jules Michel made the first experiments upon the viaducts of the Western Railway of Switzerland. About 1875 the Western Railway of France began to use a bituminous covering and 100,000 sq. m. of this material have since been put in place. Upon the Paris, Lyons & Mediterranean Ry. the viaducts built in 1848 had been protected by a coating of cement; but at the end of 25 years this cement had cracked and it was replaced at great expense, in 1875-78, by asphalt. Other railway corporations adopted the new system and the State also used asphalt largely in the protection of its fortifications. Altogether, says Mr. Malo, the area now protected by mastic asphalt aggregates 30,000 sq. m., and, as far as he can learn, no case of failure has been reported.

On the Eastern Railway of France, between 1887 and the present date about 35,000 sq. m. of the mastic asphalt have been applied to their masonry bridges, and Mr. Malo gives some of these as examples of the work done. The pure asphalt coating used is generally 15 mm. (.675 in.) thick, smoothed with a trowel and following the undulations of the extrados of the arches. The water accumulates in the hollow over each pier and is led through the arch by a metal tubing. Transversely the pure asphalt coating was carried up vertically on the inside of the side walls and at the top was connected with a footway of greater thickness made of asphalt and sand or gravel.

As the result of experience Mr. Malo thinks it would be better to apply the asphalt coating in two beds of 10 mm. thickness each instead of in one coating of 20 mm. He finds it exceedingly difficult to insure dryness in the under coating of cement, and the escaping moisture will almost inevitably produce the bubbles and vents before referred to. These vents are very minute, but if sufficiently numerous they will destroy the impermeability of the coating. For this reason he recommends that the first coat be applied as thin as practicably possible, and that a second coating of hot mastic asphalt will then absolutely close the vents left in the first. It is also essential that every precaution be taken to prevent the moisture from penetrating between the asphalt and the bed upon which it rests. In turning up the coating against a vertical side wall it would be well to cut a groove in the vertical wall bevelled from 20 mm., the thickness of the asphalt, to nothing at the bottom. This precaution adds somewhat to the expense, but it contributes in a very considerable degree to the durability and complete impermeability of the covering.

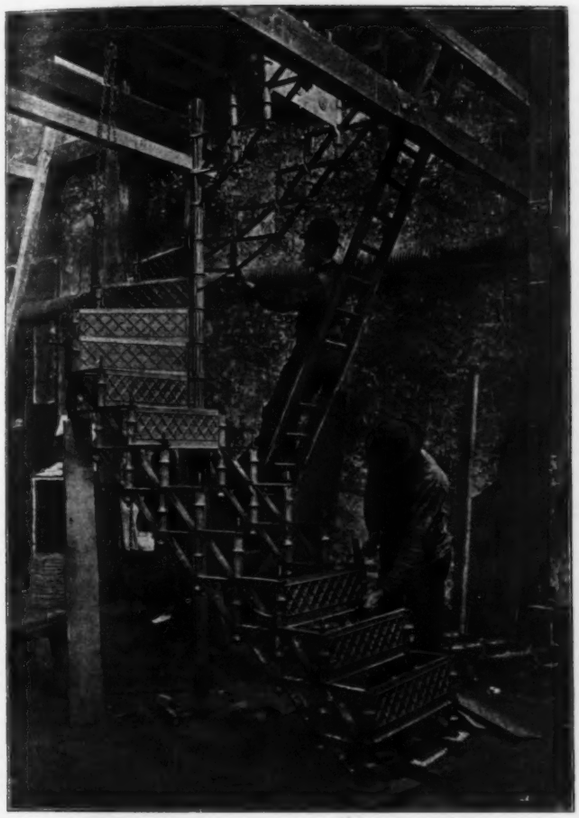


FIG. 2.--VIEW SHOWING WINDING STAIRS CONSTRUCTED ON JOLY SYSTEM.

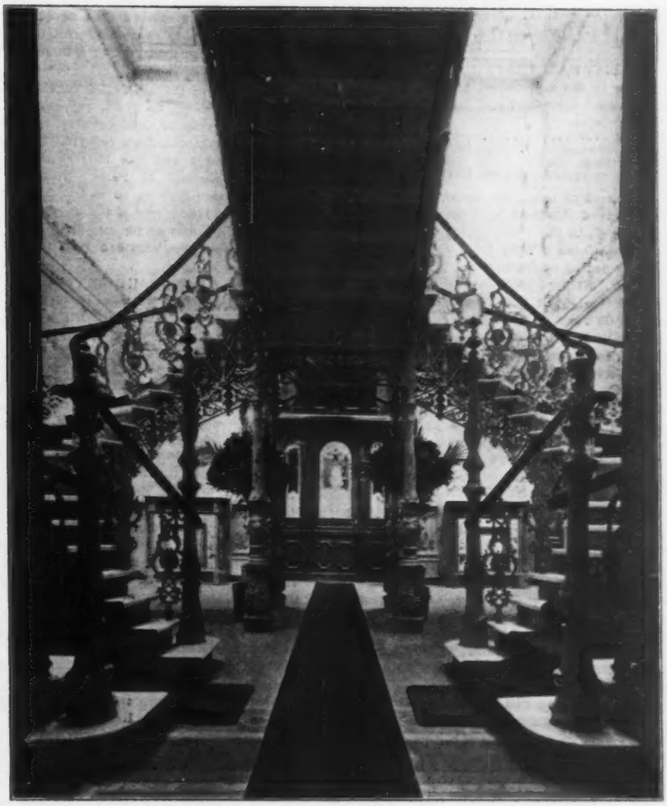


FIG. 3.--VIEW SHOWING ADAPTABILITY OF JOLY STAIR SYSTEM TO ORNAMENTATION.

A CAVE-IN OF A SEWER is feared at Long Island City, N. Y., as the engineer of the Improvement Commission, Mr. Van Alst, has reported that an examination of the new large Broadway sewer revealed the fact that the bricks were falling from the top of the arch and that fully 300,000 had already fallen. It was only a matter of time, the engineer reported, when the sewer would cave in, and in its present condition it is very dangerous. A committee was appointed to look into the case, the work having been done and paid for by the former Improvement Board.

INCREASED TRAFFIC ON THE ERIE CANAL is reported by State Statistician Ansel E. Wright. During August more coal was brought into Rochester in one day than in an entire week in 1895. From the opening of the canal to Aug. 20, 1896, 1,244 boats cleared from Rochester, as compared with 1,042 boats in the same period in 1895, and 905 boats in 1894. Detailed statements show that to Aug. 23 the increase of receipts and shipments at Rochester amounted to 60% over the same period of last year. But while the canal business is thus increasing, Mr. Wright intimates that the railways are losing a corresponding amount of trade; for while the canals, in 1895, only carried 58.7% of the total receipts of grain at New York, he expects the canal shipments of 1896 to exceed those of 1894, when they carried 94¼% of all the grain sent to New York. Every available canal boat is now being pressed into service.

SUEZ CANAL TRAFFIC, for 1893-94-95, is given as follows in the late report of the British directors of the Suez Canal company:

| | 1893. | 1894. | 1895. |
|---|---|---|---|
| Vessels .... ..... ..... | 3,341 | 3,352 | 3,434 |
| Gross tonnage ..... .... | 10,753,798 | 11,283,855 | 11,833,637 |
| Net tonnage .... ..... | 7,659,068 | 8,069,175 | 8,448,383 |
| Transit receipts ...francs | 70,667,361 | 73,776,827 | 78,103,717 |

Of the ships using the canal, Great Britain owns about 2,400 out of the total, and Germany, France and Holland come next, in the order given; though German ships have increased from 272, in 1893, to 314, in 1895. This canal was opened to traffic in 1869; in 1872 1,082 vessels passed through, with a gross tonnage of 1,744,481 tons, yielding transit receipts of 8,993,732 francs. In 1880 the number of vessels rose to 2,026, and in 1882 to 3,198, and since the latter date the number has never fallen below 3,000. But while the mean net tonnage per vessel was 1,071, in 1872, this mean tonnage was 2,460 in 1895. The average duration of voyage is now 18 h. 44 min., for vessels navigating by night as well as by day; and the average for all vessels is 19 h. 18 min. In 1895 3,206 vessels navigated the canal by night and day. Since April 15, 1890, vessels drawing 25 ft. 7 ins. have been permitted to pass through the canal.

THE BAZIN "ROLLER-STEAMER" has been launched at Paris. This craft is essentially an iron box 120 ft. long, 40 ft. wide, and 5 ft. deep, mounted upon six lenticular hollow disks or rollers, each 30 ft. in diameter and sinking into the water 10 ft. The machinery, of 750 HP., is contained in the box, and operates a screw and the six rollers, which latter pierce the box. M. Bazin expects his strange looking ship to roll over the water instead of cutting through it, and aims primarily at a vast increase of speed and an economy of fuel. He also asserts that its stability will be greater and the craft safer against danger at sea, as two rollers would keep it afloat. He proposes to navigate his ship down the Seine and across the Channel at an estimated speed of about 30 miles per hour.

THE EXPLORING STEAMER "FRAM" has arrived safely at Skjervoe, near the North Cape. The captain telegraphs that he drifted to latitude 85° 57' N., almost as far as Dr. Nansen traveled after he left the "Fram," in August of 1895. All were well on board, and a deepest sounding of 13,110 ft. and a lowest temperature of 52° below zero are reported.

A FLOATING STATION for the U. S. Life-Saving Service is to be anchored in Boston Harbor. It is a triangular craft, 100 ft. long, 33 ft. beam at the stern and 12 ft. deep. The lifeboats are swung inside, on each side of an opening 20 ft. wide which extends inward from the stern for a distance of 30 ft. This is roofed over and here the boats can be easily launched, the vessel being anchored by the bow so that the boats will row off under the lee of the floating station. The vessel was designed by Mr. Kimball, Superintendent of the U. S. Life-Saving Service.

THE AIR-SHIP OF CHARLES H. LAMSON made a very successful ascension at Portland, Me., on Aug. 20, and aerial experimenters declare his achievement the greatest step yet made towards solving the problem of aerial navigation. The "air-ship" used was really a box-kite made of two oblong boxes, parallel to each other and connected at the middle. It is the Hargrave ship with improvements by Mr. Lamson, tending to improve the steering qualities by hinging the rear cells of the boxes, etc. The ship was provided with a dummy weighing 150 lbs. seated in the car; it was secured by a line tested to a pull of 500 lbs., and when the forward end was slightly lifted and a short run taken it ascended steadily and safely to a height of about 600 ft. At this point a sudden gust of wind broke the cord and the ship sailed on for about half a mile and then gently descended. Had a man been in the car to attend to the steering apparatus Mr. Lamson claims it would have safely ascended to a still greater height, and as easily descended.

AN AIR SHIP OR NAVIGABLE BALLOON is being built by Cusab Bros., of Walkerton, Ind. The balloon is cigar-shaped, 15 ft. long and 4 ft. diameter, with one propeller at the rear and two at the front. A car is suspended below the balloon.

TWO MAIL-COLLECTING AND SORTING WAGONS are being built at Hartford, Conn., for the post office service. Each wagon has a body 12 ft. long by 5 ft. wide, and 6½ ft. high, which is fitted with all conveniences for sorting, cancelling and pouching the mail as fast as collected. Two horses will be used with each wagon, and there is room for two clerks inside. It is proposed to make collections continuously, the carriers emptying the street-boxes and bringing the mail to designated points on the routes. It is estimated that from two to three hours can be thus saved in sending mail to its destination, as compared with the old system requiring all mail to be first sent to a main sorting and distributing center.

BICYCLES ARE TAXED IN FRANCE at the rate of 10 francs, or $1.93, per annum. The popularity of the bicycle in that country is thus indicated in the national tax-collector's reports. This tax was imposed on April 29, 1892, and now 160,000 machines are on the tax-lists. "Le Matin," of Paris, estimates that there is now in use one bicycle to every 250 persons of the population of France; and if the aged, young children and the majority of women be excluded, there is one bicycle to every 50 persons who can ride.

A STORAGE BATTERY ELECTRIC CAR, built by the Electric Storage Battery Co., of Philadelphia, is to be tried on the 34th St. branch of the New York elevated railway.

## BOOK REVIEWS.

THE ENGINEERING INDEX.—Volume II., 1892-1895. Edited by J. B. Johnson, C. E., Chairman Board of Managers, and Manager of the Index Department of the "Journal of the Association of Engineering Societies." Associate Editors: F. E. Turneaure, C. E.; C. B. Stewart, C. E.; J. L. Van Ornum, C. E. New York: The Engineering Magazine. 8vo.; pp. 474. $4.

As a labor-saving device this index ranks high among the aids to the engineer. In fact, it does more than save him labor; it points him to sources of information which it would be next to impossible for him to discover for himself.

The matter indexed, as many of our readers know, is that appearing in the leading engineering and allied periodical publications of the world. The index originally appeared in the monthly numbers of the "Journal of the Association of Engineering Societies" during the past four years, and is here brought together in convenient form. Vol. 1. was published in 1892, and covered the period from 1884 to 1891, inclusive, so that the two volumes include what has appeared in the engineering periodicals for the past eleven years. For the convenience of our readers it may be stated that copies of the first volume can still be obtained from Mr. John C. Trautwine, Jr., Assoc. M. Am. Soc. C. E., Secretary of the above-named association, 257 Fourth St., Philadelphia.

For many years the index work carried on by Professor Johnson was the only thing of the kind, for engineers, but lately the "Engineering Magazine" has been covering about the same ground. This fact finally led to an arrangement by which the journal was to publish Professor Johnson's index for the past four years in one volume, and bring out a yearly volume of a similar nature, the index in the "Journal of the Association of Engineering Societies" to be dropped after the close of 1895.

The volume before us, like its predecessor, aims to be more than an index, in that it gives under many of the entries some idea of the nature and extent of the article, thus enabling the user to decide, in some cases, whether the article contains the particular information which he desires.

While we cannot speak too highly of the usefulness of this volume, yet it has its faults, and they are serious ones. They relate, however, not to the matter included, nor the comments upon the articles indexed, in all of which most excellent judgment seems to have been used. The greatest fault of the book is that after the matter for it was extracted from the various sources, assorted into classes and the classes arranged alphabetically, the work was then to a large extent stopped, without making any logical arrangement of the matter in each class.

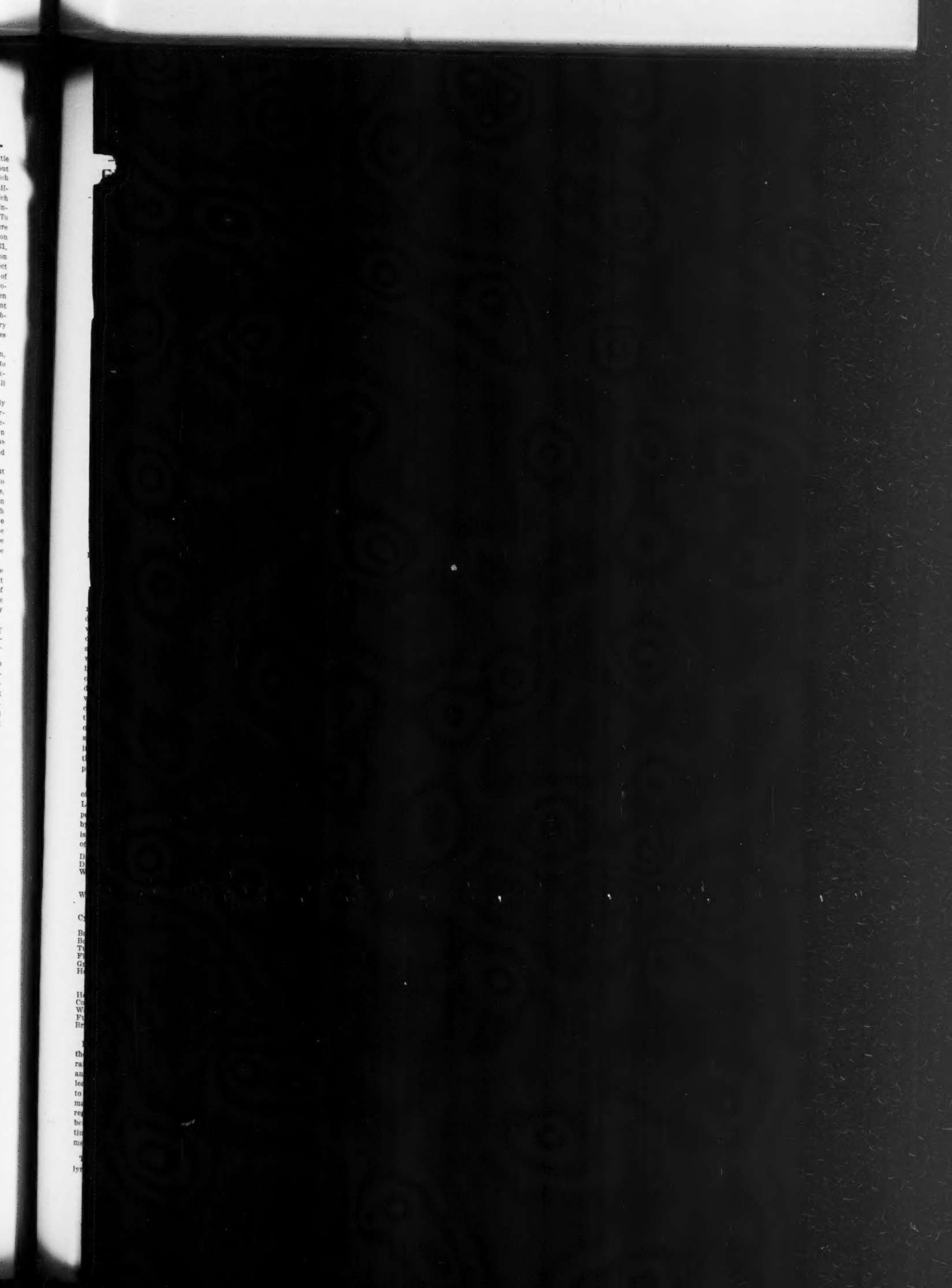
Where the number of entries under a given subject are few, like copper, dredging or flume, this matters little to the user, although none the less bad indexing, but when one wishes to find something under boilers, which occupies eleven pages, or bridges, with 25 pages, or railroads, with 32 pages, much time must be spent which might have been, and should have been, saved if the indexer had carried his task to its logical conclusion. To make this plainer, let us take up boiler explosions. There are two references to this subject on page 24, three on page 25, one on page 29, two on page 30, one on page 31, and four on page 32, and in most cases the entries on one page are separated. Or, instead of a general subject like boiler explosions let us take a specific structure of note, as the Memphis Bridge. Bridge and bridges together extend from page 38 to page 63, and there are ten entries relating to the Memphis Bridge on eight different pages beginning with the first page devoted to the subject, and ending with the twenty-first, thus: one entry each on pages 38, 46, 53, 54, 56 and 58, and two entries each on pages 45 and 57.

The criticisms thus far made are for sins of omission, rather than commission. Further criticisms relate to matters of judgment connected with the art of index-making, instead of the failure to complete the task in all its details.

The classification of subjects seems to overlap greatly in instances that cannot at all be classed as cross-references. Under "Railroads" are entries on electric and elevated roads, but both these sub-heads have their own place in the book, to which reference must be made, as well as to railroads, to find all that has been published on these subjects.

The references from one subject to another throughout the work, while in many cases valuable, seem carried to excess. Thus under "Iron" we are told to "see" alloys, bridges, buildings, iron and steel, cast iron, wrought iron and numerous other subjects, 28 in all, some of which are merely sub-divisions of the subject and should have appeared under it, instead of being scattered through the book. These lists are often placed at the middle of the section, instead of at the beginning or end, as would be expected.

No one should be deterred from securing this valuable reference book because it does not accomplish all it might when it has done so much to lighten the labors of the engineer and point out sources of information, the mere existence of which he would not and practically could not otherwise know.

GENERAL SPECIFICATIONS FOR STEEL HIGHWAY BRIDGES AND VIADUCTS.—New and revised edition, 1896. By Theodore Cooper, Consulting Engineer. 8vo.; pp. 25; 25 cts.

The last edition of the highway bridge specifications was published in 1890, but since then methods of manufacture and construction have been improved and modified, and conditions of traffic, as affecting loads on street and highway bridges have been changed. This new edition of the specifications has therefore undergone several important changes and modifications. Iron has been left out altogether, as in the new railway bridge specifications, and the classification and requirements of steel there given have been adhered to. In the arrangement of different classes of bridges important changes are noticed. It has been found necessary to provide five different classes for varying requirements of traffic and loading, instead of only three, as in the former edition. Class A 1 is entirely new, calling for a buckle plate floor with regular street pavement, an addition certainly needed in view of the growing demand for substantial bridges in the larger cities, furnishing, in fact, an unbroken street surface. One of the most important changes, which will have an influence in materially improving the safety and reputation of highway bridges, is in the provision for loading. The enormous growth of electric railways with cars far heavier and speedier than the old-fashioned horse cars, and frequently exceeding in weight all other classes of vehicles, has occasioned important changes in the loading provided for the other classes, both for suburban and town bridges. The light loads are thus left for comparatively unimportant country bridges, where there is no probability of electric railway construction, and where the loads from other sources are relatively light. The allowed tensile strains on truss members are practically the same as they were before for medium steel, but the allowed strains on floor beams and stringers have been reduced from 14,400 to 13,000 lbs. per sq. in., and the unit strains on floor-beam hangers have also been reduced. This reduction of the unit strains on members of the floor system is undoubtedly made in consideration of the electric car traffic, with high speed and frequent application of the loads. The formulas for unit strains on compression members have also been modified, especially those for posts. A special formula has been given for posts of deck bridges and trestles, allowing higher strains than on posts for through bridges. The chapter dealing with details of construction is in all essential features the same as that of the railway specifications, with some minor changes in the requirements for minimum thickness of metal, size of lattice bars, etc. As to workmanship the two specifications do not differ.